Econometric Analysis of Exchange Rates in East Asia

A thesis submitted to Middlesex University
in partial fulfilment of the requirements for the degree of
Doctor of Philosophy

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December 1999

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Abstract

This study is concerned with the behaviour of exchange rate movements focusing specifically on purchasing power parity (PPP) and the non-stationarity of real exchange rates, for a number of East Asian currencies during their recent floating periods. As one of the most important building blocks in international economics, PPP forms a core component of several models of exchange rate determination, and it is the most intensively tested hypothesis in open-economy macroeconomics. Nevertheless, in contrast to the relative abundance of research on the currencies of industrialised countries, very few studies on East Asian currencies have been carried out, leaving an important gap in the literature.

Using recent advances in time series analysis, the results reveal for the East Asian countries that there existed long-run comovement between the nominal exchange rate and domestic and foreign price levels, but that the strict PPP condition claimed by the theory did not hold. This implied that any deviation from the PPP equilibrium was permanent and that there was little tendency for the real exchange rate to be mean reverting. Further investigation suggested that the real exchange rate was cointegrated with fundamentals, with most of the variables entering the cointegration vector significantly, suggesting that the movements of real exchange rate were driven by these factors.

Investigating the dynamic paths of the real exchange rate and the long-run relationship (cointegrating relationship) in response to exogenous shocks also revealed that the real exchange rates did not revert to their pre-shock equilibrium, but that the long-run

relationship did. It took, normally three to five years, for the real exchange rate to reach and settle down to a new equilibrium and even if the effect of shocks on the long-run relationship was transitory, the speed of convergence to the equilibrium was slow. The results also showed that the effects of shocks vary from one country to another. This meant that there was no universal panacea to deal with fluctuations in real exchange rates, as they were influenced by a country's natural endowment, stage in industrialisation, as well as monetary and exchange policies.

Acknowledgements

I wish to express my gratitude to a number of individuals who have supported me to do this research.

First of all, I am deeply grateful to my director of studies, Professor Paul Dunne, for his most valuable advice, guidance and support over the last three years. His time and thoughtful comments on my work are greatly appreciated.

I am indebted to Maria Lane, Claire Dutton, Louise Stroy and other members of staff in MUBS for their kind support.

Many thanks also go to library staff at Hendon for getting articles and books I needed during my study.

I am also appreciative of the studentship granted by the MUBS, which gave me the opportunity to do this research.

Finally, I am grateful to my family for their support and encouragement which enable me to complete this thesis.

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A version of Chapter 6 has been accepted as "Testing PPP for Asian economies during the recent floating period," forthcoming in April 2000 in *Applied Economics Letters.*

A version of Chapter 7 has been accepted as "Sources of movements in real exchange rates - Evidence from East Asian economies", forthcoming in March 2000 *Weltwirtschaftliches Archiv.*

A version of Chapter 8 has been submitted to *The Asian Economic Journal* entitled "Real exchange rate fluctuations in East Asia - Impulse response analysis."

Chapter 1

Introduction

1.1 Background

This research studies the behaviour of exchange rates during the recent floating period for seven East Asian countries in an econometric analytical framework. In particular, purchasing power parity (PPP) and its extensions will be investigated. PPP states that nominal exchange rate should equal the relative price between two countries. In other words, the theory predicts that real exchange rates will tend to return to a constant long-run equilibrium in response to short-term shocks and, therefore, that nominal exchange rate movements should offset relative price changes between two countries. It is one of the main relationships within any open economy macro model and is used, implicitly or explicitly, as a long-run relationship in the monetary models following Frenkel and Johnson (1978), which assumes that PPP holds continuously. Sticky price exchange rate models following Dornbusch (1976) allow the exchange rate to deviate from PPP in the short-term, but retain it as a long-run equilibrium condition. In addition, PPP is often used for comparing international real purchasing power by using a common currency and nominal exchange rates, and serves to provide a measure for the level of an exchange rate in policy discussions.

For these reasons, PPP is one of the most extensively tested hypotheses in open-economy macroeconomics, and it can be viewed as the open-economy extension of the quantity theory of money. According to PPP, nominal disturbances will have no permanent effects on the real exchange rate. If PPP holds, it implies that the nominal exchange rate is adjusted for inflation differentials and the real exchange rate is stationary. If, on the other hand, PPP is rejected it implies that exchange rate does not depend on relative prices and just follows a random walk process. Non-stationarity in the real exchange rate has many macroeconomics implications. For example, Dornbusch (1987) has argued that if the real exchange rate depreciates, it could bring a gain in international competitiveness, which in turn, could shift employment toward the depreciating country. If, on the other hand, the real exchange rate appreciates, it serves to reduce inflationary pressure as the rate of increase of traded goods prices is pushed below the prevailing rate of inflation. Therefore, it is important to establish the empirical validity of the PPP theory.

When exchange rates started to float world-wide in 1973, it was widely believed that exchange rates would adjust according to relative prices. However, years of highly volatile exchange rates destroyed that illusion,[1] and in the early 1980s it seemed as if interest in the theory of PPP had collapsed completely. In recent years, however, with the availability of more data and new developments in econometric techniques - in particular, new advances in time series analysis, PPP has been receiving a great deal of attention in new empirical studies.[2] Recent interest in testing for PPP, based on time series data, has been revived at least in three fronts. First, univariate time series has been used to pick up slow mean-reversion; second, more than one time series have been used to detect the comovement among the variables; and third, panel data sets, consisting of many countries, are employed

[1] The comprehensive review of the behaviour of exchange rate for the recent floating period can be seen in MacDonald and Taylor (1992), MacDonald (1995), Rogoff (1996) and Taylor (1996).
[2] See Breuer (1994) and Bleaney and Mizen (1995) for a survey.

to complement the shortness of time series data. To date, however, no conclusive result has been achieved.

The first approach examines the time series property of real exchange ratc behaviour by conducting unit root tests. If PPP is a strong driving force, the real exchange rate should have a tendency to move back to an equilibrium indicated by PPP, and the null of a unit root should be rejected.[3] Examples of such studies include Darby (1983), Adler and Lehman (1983), Hakkio (1984), Frankel (1986), Edison (1987), and Meese and Rogoff (1988); Taylor and McMahon (1988), Choudry *et al* (1991), and Flynn and Boucher (1993). Researchers have generally found that real exchange rates for many countries over the post-Bretton Woods era do contain a unit root.[4] This finding implies that real exchange rates are non-stationary, suggesting that PPP as a long-run stable relationship does not hold.

The second approach based on time series data applies cointegration methods, which interprets PPP as a co-integrating relationship between the nominal exchange rate and relative national pricc levels. The cointegration procedure attempts to examine if several variables, although non-stationary individually, move together. Example can be seen in Corbae and Ouliaris (1988), Enders (1988), Kugler and Lenz (1993), Pippenger (1993) and

[3] In other words, simple PPP requires that real exchange rates be stationary and revert to long-run stable trends with short-term fluctuations around these trends.

[4] However, the apparent failure of PPP is due to a lack of power, according to Lothian and Taylor (1996, 1997). To increase the power, several studies use long time periods, for example, Frankel (1986), Abuaf and Jorion (1990), Lothian (1990), Diebold *et al* (1990), Grilli and Kaminsky (1991), Glen (1992), Becketti *et al* (1995) and Lothian and Taylor (1996). Their results suggest that the real exchange rate is not a random walk, and that shocks to the real exchange rate damp out over time, albeit very slowly. However, using very long time series to solve the power problem, as Frankel and Rose (1996) pointed out, encompass period in which nominal exchange rate regimes shift from floating to fixed and back again. From the statistical point of view this may raise the equation, since the data generate process is likely to be sensitive to the exchange rate regime.

MacDonald (1993). Some authors have found cointegrating relationships between the nominal exchange rate and two relative national price levels, but these relationships do not support unitary coefficients implied by PPP.

The third approach is to use the panel data set. The motivation of using panel data is to increase the power of testing PPP, as if the speed of convergence to equilibrium is very slow, long time series are needed to rule out the hypothesis that the series follows a random walk process. In contrast to attempts to develop longer time series of data, the panel approach allows researcher to increase power of test while using only post-Bretton Woods data, by pooling across many different real exchange rates. This approach avoids the problem of dealing with different exchange rate regimes. Examples of this kind include Frankel and Rose (1996), Jorion and Sweeney (1996), Liu and Maddala (1996), Lothian (1997), MacDonald (1996), O'Connell (1998), Oh (1996), Papell (1997), Parsley and Wei (1996), and Wu (1996), with mixed results.

Faith in the PPP doctrine is, however, still seriously challenged by empirical evidence from the recent floating exchange rate experience using pairs of countries. After more than 25 years of experience of floating, exchange rates are dominated by high variability, much higher than was expected by the advocates of the system.[5] The stylised facts of the recent float include high volatility of real exchange rates, very high correlation of changes in real and nominal exchange rates and the absence of strongly mean-reverting properties in either series, see, for example Frankel and Mussa (1980), Frankel and Rose (1995), and Taylor (1995). Mussa (1986) compares the extent of short-term deviations from

[5] For example, see the text books by Hallwood and MacDonald (1994), and Pilbeam (1992).

PPP under fixed and floating exchange rates, and found that floating exchange rates systematically led to much larger and more frequent short-term deviations from the relative PPP hypothesis .

One of the explanations for the above fact is the existence of real factors, suggesting that shocks to real exchange rates have infinitely long-lived effects.[6] People holding this view explain that if the predominant force upsetting the PPP relationship is nominal, or monetary, it will have only a transitory effect on deviations from PPP, as a result, the long-run PPP should hold. If, however, the sources of PPP disturbances are truly 'real' in nature, one would argue that they will have a permanent effect on the real exchange rate, and consequently, simple PPP is not expected to hold. In this regard, Balassa's (1964) appraisal of the PPP doctrine makes an important contribution to the development of such an argument. He conjectures that productivity increases in the tradable sector tend to be higher than those in the non-tradable sector, so that the conventionally constructed real exchange rate (using a price index including both traded and non-traded goods sectors prices, such as CPI) will move in response to cross-country differences in the relative speed of productivity increases between the tradable and non-tradable sectors. Thus, the productivity differentials can be thought as one of the major factors contributing to the deviation of PPP from the equilibrium exchange rates. This suggests that permanent real disturbances are the predominant sources of real exchange rate fluctuations and that theoretical or empirical modelling of the underlying determinants of PPP deviations should focus primarily on real factors.

[6] For the references, see the footnote 1.

Reviewing the previous literature, it can be seen that tremendous efforts have been made in testing the validity of PPP. Typically, however, PPP has been tested among the developed countries, which have been traditionally linked in economic, trade and even geographical terms. In addition to the earlier influential studies by Frenkel (1978, 1981), Krugman (1978), and Dombusch (1976, 1980), a large body of recent research includes Taylor (1995), and Ott (1996), and more recently, Sarno and Taylor (1998), Cheung and Lai (1998), Papell and Theodoridis (1998). Of studies which search for the impact of real disturbances, examples can be found in the papers by DeLoach (1996), In and Menon (1996), Dutton and Strauss (1997), and Amano and Norden (1995, 1998) who investigate whether a link exists between the real exchange rate and some specific factors, such as productivity differentials, terms of trade, and the real price of oil, and Dibooglu (1996), Zhou (1995), MacDonald (1997), Strauss (1999), and Feyzioglu (1997) who explore whether a group of factors, or so called fundamentals, cause permanent changes in real exchange rates.

However, despite this ever-growing literature, few studies have investigated the PPP proposition for the developing countries and even less have been investigated in the East Asian area. Given the differences in market structure, production, trading processes, and consumer tastes and behaviour between these countries and the developed economies, they represent an important focus for research. Although there are limited studies for the East Asian region,[7] further scrutiny is clearly desirable, as these researchers admit that their empirical results, which appear to reject the random walk hypothesis in real exchange rates and the long-run PPP, often contradict each other and provide no clear-cut conclusions. With few

[7] These include Abeysinghe and Hong (1992), Ahmad and Ariff (1997), Bahamani and Rhee (1996), Lin and He (1991), Kim (1995), Moosa and Bhatti (1997), Wu (1996), Phylaktis and Kassimatis (1994), and Chinn (1996, 1997).

exceptions, the majority of the research is on single currency, which makes comparison difficult as the studies also vary in the methodologies, data and time periods.

Furthermore, as one of the fast growing regions in the world with the considerable and continuing changes in industrial structure, trading activity, and market mechanisms, the East Asian region provides an interesting example to investigate whether there exist trend deviations from PPP, or in other words, if there exist real factors to cause the permanent changes in real exchange rate. Since the Balassa-Samuelson hypothesis should be most visible among rapidly growing countries, therefore, the East Asian economies, with fast growth rates, would provide a useful test of this hypothesis. There is some evidence that relatively fast-growing countries do experience real exchange rate appreciation. For example, Marston (1987) studied the impact of productivity differentials on the yen/dollar real exchange rate and found that the real appreciation of the yen over the past two decades was generally associated with the relative rapid expansion of output in Japan. The question whether rapid output growth tends to be associated with real exchange rate appreciation in general- that is, whether Japan's experience extends to other economies - has been an important topic of investigation in empirical research on the long-run behaviour of exchange rates. However, with regard to investigating real fundamental shocks, as far as the author is aware, little work has been done in the East Asian area, with exception of Bahmani-oskooee and Rhee (1996), Isard and Symansky (1996), Ito *et al* (1997), and Chinn (1997). What is needed is new and comprehensive studies covering the major players in the region, with not only a regional but also a world perspective. This study makes a contribution to this point.

1.2 Objectives and organisation of the thesis

The countries to be studied are Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, and Thailand.[8] The Asia Pacific area in general and these economies in particular had demonstrated tremendous progress, a development that was described by the World Bank as *The East Asian Miracle*, and have been in financial turmoil, starting from the end of 1996. The research inquires into the long-run behaviour of the exchange rate of these countries by examining their times series properties, in the framework of cointegration and error correction modelling, proposed by Engle and Granger (1987), Johansen (1988), with further extensions by Johansen and Juselius (1990, 1992), Osterwald-Lenum (1992) and Juselius (1995). This approach is, in theory, able to present and reveal crucial economic relationships consistent with underlying time series properties and this has led to the recent developments in cointegration and its testing procedures attracting immense attention from researchers studying for PPP. This thesis aims to test the validity of PPP, examine the trend movements in real exchange rates, and identify the real factors that have the most important impacts on the exchange rate. Specifically, the present study attempts to fulfil the following objectives:

First, it will test for the validity of the PPP hypothesis. Focusing on seven East Asian economies during the recent floating rate period, it tests for the long-run cointegrating relationship between the nominal exchange rate and domestic and foreign price levels, with and without restrictions on the PPP parameters. It will further assess the short-term dynamics to see how the disequilibrium is corrected via the error correction mechanism (ECM) model.

[8] Although the Japanese yen is extensively studied by other authors, the inclusion of Japanese yen can be used to compare the exchange rate behaviour with other East Asian countries.

Second, it will explore the long-run relationship between the real exchange rate and fundamentals. As is well known, most of the East Asian economies included in our sample experienced faster economic growth than the US during the last two decades. As a result, factors such as productivity bias may affect tests of parity reversion in the real exchange rate. So our empirical examination then focuses on the role of real factors in the determination of real exchange rate movements.

Third, it will reveal the time path of various shocks to real exchange rates. Using impulse response and forecast error variance decomposition analysis, this study tests the relative importance of the bias, if any, introduced by the real disturbances, and examines how the real exchange rate reacts and responds to real shocks and evaluates how long it will take the real exchange rates to return to equilibrium after a shock occurs.

The rest of the thesis is organised as follows. Chapter 2 gives a broad view of each country's economic performance with regard to growth and price stability, in relation to industrial structure, natural resources, and exchange rate policy. These economic indicators and factors have, to a varying degree, an impact on the movements in exchange rate and validity of PPP in a country.

Chapter 3 and Chapter 4 give the theoretical background of this thesis. Chapter 3 focuses on the relationships between the nominal exchange rate and domestic and foreign price levels, i.e. the PPP hypothesis, and the implication of the hypothesis for the mean reversion of real exchange rates. It reviews the most recent literature on PPP, from the unit root tests of real exchange rates, to long-run cointegration tests of PPP, and panel unit root tests of real exchange rates. It then explains the problems arising from the testing of PPP and points out three modifications in testing for the hypothesis.

Chapter 4 further explains the incompleteness of simple PPP. Because of the existence of traded and non-traded goods, the relative price changes between them might cause the permanent movements in real exchange rates. The emphasis here is then devoted to the relationship between real exchange rate and real economic variables. These include decomposing the real exchange rate, examining the influence of the relative price of non-tradables on real exchange rate movements and analysing the possible sources of causing changes in the relative price of non-tradables.

Chapter 5 offers a discussion of recent developments in econometric methodology and estimation techniques and their implications to the testing of PPP hypothesis and long-run equilibrium real exchange rate. These include unit root tests which focus on the time series properties of the real exchange rate, cointegration tests which examine the comovement among several economic variables such as nominal exchange rate, domestic and foreign price levels. These two approaches constitute the basic methodology and are heavily used in present empirical work.

Chapters 6 to 8 provide the empirical studies of the behaviour of exchange rates for the modern floating period. Chapter 6 begins with the test of the simple PPP, i.e. focusing on the relationship between the exchange rate and the relative price levels of two countries, including unit root tests of the random walk hypothesis for the real exchange rate, cointegration tests between the exchange rate and relative price levels. The disequilibrium adjustment under the error correction model is also assessed.

Chapter 7 then investigates the relationship between the real exchange rate and fundamentals. The survey of the theoretical issues suggests that fundamentals might have an impact on the movements of real exchange rates. The chapter starts with identifying these real factors and then an empirical model is set up to test the relationship between real exchange rates and these fundamentals using the cointegration method. For the cases when the cointegration relationship are confirmed, the dynamic movements in real exchange rates is further explored.

Chapter 8 focuses on the analysis of fluctuations in real exchange rates. Taking the real factors identified in the previous chapter, this chapter measures the relative contributions of each shocks to the forecast error variance of real exchange rate and traces out the time paths of the real exchange rates and the long-run relationship (cointegrating relation) as they response to various shocks to the variables. In a sense, this chapter extends the static results obtained over a given period to a dynamic analysis of the real exchange rate in the future.

Finally, a summary of the thesis and the conclusions drawn together with suggestions for further research are presented in Chapter 9.

Chapter 2

Economic Background in East Asia

Introduction

Over the past decades up to the recent financial crisis started in 1997, many countries in the East Asian area had experienced a dynamic process of economic development, driven to a considerable degree by trade liberalisation and economic reforms. As a result, the economic achievements of the countries in this region had little in parallel with the West, and their growth rates were significantly above the high-income economies' average. This chapter will give a broad view of each country's economic performance with regard to growth and price stability, in relation to industrial structure, natural resources, and exchange rate policy. These economic indicators and factors have, to a varying degree, an impact on the movement in exchange rate and the PPP position of a country. By carrying out such analysis, we can get the economic development in this region in general and exchange rate movement in specific. In what follows, section 2.1 gives the general picture of the economic development of the area as a whole, and section 2.2 focuses on the individual country.

2.1 Overview

The seven economies, namely Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore and Thailand, are highly diverse economically and socially in terms of size, historical background, natural resources, culture, and political institutions. However, they have a number of common economic characteristics that can distinguish them as a group. First, although the extent of government intervention varies among the economies, they are all market-based economies. Second, they are all export-oriented with a high degree of export dependence. Third, they have common economic aspirations with much emphasis placed on economic growth as they had generally a long history of underdevelopment and poverty. Fourth, except for Singapore, these economies are dualistic where more than 50 percent of their population live in the agricultural and rural sector. These commonalties have bound them together in their pursuit of greater economic development and improvement of the life of their respective constituents.

Table 2.1 summarises the diverse stages of development and the rapid growth of these countries, as well as the comparison with other groups of countries. The relative rapid growth rates can be seen in the middle of the table. It is clear that the seven economies grew more rapidly and more consistently than any other group of economies in the world from 1960 to 1996. Over the period 1970-1996, almost all of the countries had enjoyed average annual growth rates in excess of 7 percent, except the Philippines where the annual rate was about 3.7 percent during this period, well above that posted by the developed market economies (around 3 percent) and significantly above the world average growth rate (around 2 percent).

Because of sustained high growth rates during the last three decades, the standards of living, as measured by GDP per capita, had consistently enjoyed increases. This fact is also illustrated by the first (year 1970) and the last (year 1996) columns of Table 1.1, both in the 1996 price in terms of the US dollars. It is obvious that these countries have graduated from the ranks of low income countries, to the ranks of middle and in some cases upper-middle income countries. During this period, the real GDP per capita in Singapore had risen nearly 10 times; the figure was 5 times in Korea; and more than threefold in Indonesia, Malaysia, and Thailand over this period. The Philippines had GDP per capita risen around twofold.

Table 2.1 GDP growth and GDP per capita in East Asian countries

	GDP Per Capita (in 1996 US dollar)	Real GDP Growth (Annual average; in percent)			GDP Per Capita (in 1996 US dollar)
	1970	1971-79	1980-89	1990-96	1996
Indonesia	388	7.8	5.3	8.0	1,119
Japan	20,135	3.4	4.0	2.2	38,571
Korea	1,914	9.4	8.2	7.5	11,034
Malaysia	1,503	8.1	5.8	8.7	4,652
Philippines	663	6.3	2.0	2.7	1,179
Singapore	3,328	9.1	7.3	8.3	31,787
Thailand	658	7.1	7.4	8.8	3,116
US	19,455	3.2	2.5	1.9	28,766
Western Hemisphere	2,752	6.2	2.3	2.7	3,530
Sub-Saharan African	541	3.4	2.9	2.5	332

Sources: International Monetary Fund, World Economic Outlook: A Surrey by the Staff (Washington, various issues); and IMF staff estimates.

According to GDP per capita, the seven countries under consideration can be classified into three categories.[1] Japan has clearly joined the ranks of rich industrial countries; because of strong, sustained economic growth since 1970, both Korea and Singapore have joined the ranks of the newly industrialised countries; while Indonesia, Malaysia, the Philippines, and Thailand remain developing economies. GDP per capita in

[1] Based on IMF classification. For the details see World Bank (1993).

Malaysia and Thailand represent 16 and 11 percent respectively of that prevailing in the US in 1996, and with Indonesia and the Philippines being around 4 percent.

Accompanied with the high speed of growth are rapid changes of industrial structure. Typically, as an economy develops, agriculture's share in the economy declines. The six economies with substantial agriculture's sectors - Indonesia, Japan, Korea, Malaysia, the Philippines and Thailand[2] - have been making this transition rapidly (see the next section). Moreover, the countries of interest in this study have completed, or have been experiencing, a transformation from an agricultural, stagnant economy to a manufacturing, export-oriented, growing economy. It is obvious that such success is based on the change in industrial structure, gradually moving up on the technological ladder. In many countries, economic development changed the structure from low value-added-goods sectors, such as primary goods and textiles, to high value-added-goods sectors, such as metal products, electronics and machinery sectors. Moreover, each sector changes its trade status from a net importer to domestically self-sufficient, then to a net exporter.

Apart from the high growth rate and dramatic structural changes of the economy, other outstanding characteristics presented by this group of economies are the rapid growth of exports, high investment and savings rates and rapid productivity growth[3]. However, the recent slowdown in Asian growth - the currency crisis that began in Thailand in mid-1997 and rapidly spread throughout South East Asia - turned into a widespread regional contraction in 1998. None of the countries in the sample seems to be able to avoid this

[2] Singapore almost lacks agricultural sector.

[3] That labour productivity in the region increased rapidly is self-evident: per capita GDP growth depends primarily on rising output per worker.

crisis. As a result, Indonesia, Japan, Korea, Malaysia, the Philippines and Thailand all suffered, to a varying degrees, economic contraction. Singapore was also unable to avoid the impact of the regional slowdown with GDP growing only 1.5 percent. The crisis revealed that a careful sequencing of reforms was necessary[4]. In the next section, each country's economic development will be broadly reviewed in order to get general picture of the economic development in this region.

2.2 Each country's perspective

2.2.1 Indonesia

• Background

Indonesia is a country with a territory of 1919,317 square km and a population of 201.4 million (mid-1997 estimate), being the fourth most populous country in the world. The large size and geographic diversity gives it the capacity to produce a wide range of agricultural products. It is also endowed with a rich variety of mineral resources, including both onshore and offshore deposits of petroleum and natural gas as well as large reserves of coal. Due to its large domestic market, relatively low-cost labour and political stability under the Suharto regime, Indonesia has for some time been attracting foreign and domestic investments into its manufacturing sector, resulting in a more diversified economy. The country had achieved remarkable economic development success over the past decade and until recently was among the best performing East Asian economies. The most obvious achievement over the last three decades is poverty reduction. Between 1970 and 1996, the proportion of the population living below the official poverty line declined from 60 percent to 11 percent[5] -

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[4] The key factors that contributed to the crisis have been discussed in detail in the December 1997 and the May 1998 World Economic Outlook, IMF.
[5] See World Bank Publication "East Asia: The Road to Recovery", 1998.

about 28 million people - reflecting the government's strong commitment to poverty reduction.

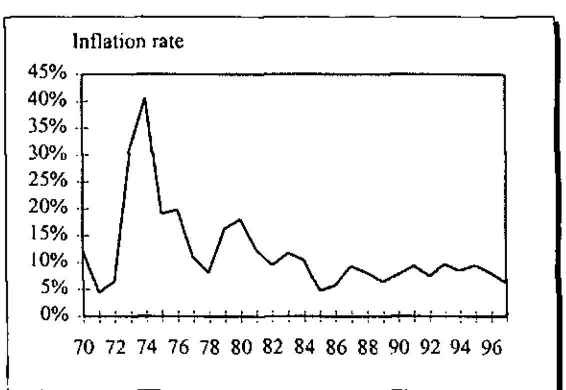
• Political history

The republic of Indonesia is formally a constitutional democracy with a string executive presidency. It was under the colonisation of Japan beforc it proclaimed the independence in 1945. The first 15 years of Indonesia's history as an independence state, under the leadership of Sukarno, were marked by political instability and economic decline. The liberal democratic republic established in 1950 was characterised by frcquent changes in cabinets, regional revolts and cconomic mismanagement. The situation deteriorated after 1959, when president Sukarno dissolved the elected House of Representatives and replaced it with a Provisional People's Consultative Assembly. This era of Guided Democracy was a period of political turmoil. Then it came the September 1965 coup which marked the end of the Old Order. In March 1966 the New Order was established when the executive power of government was transferred to Major General Suharto. He became acting president in March 1967. Since then the country had been under his rule for more than 32 years until he was forced to step down in 1998 among political and economic turmoil. The country has recently held, to some extent, democratic general elections.

• Economic structure

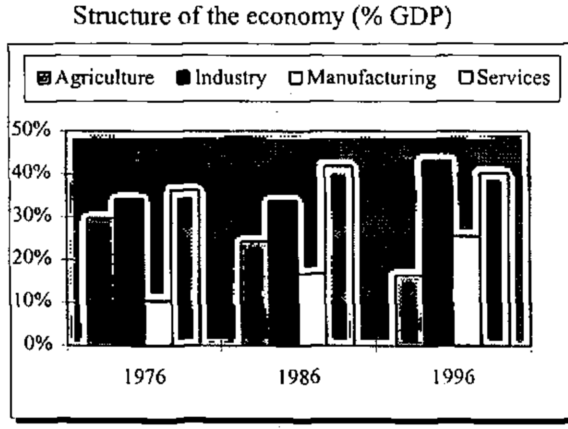
Indonesia has a reasonably well-balanced economy in which all major sectors play an important rolc. Agriculture (including animal husbandry, fishing and forestry) has historically been the dominant activity, in terms of both employment and output. Thcre is a vast range of mineral resources, the extraction and exploitation of which have proceeded rapidly during the past decades, enabling the mining sector to make an important contribution to the balance of payments. The manufacturing sector also expanded dramatically during the New Order period, because of the heavy investment in this sector, and especially since the mid-1980s. The manufacturing sector grew at annual rate well in excess of the rate of overall GDP growth. Its share of GDP rose from 10.4 percent in 1976 to 16.8 percent by 1986, and reached 20.8 percent in 1991, surpassing that of agriculture (19.6 percent of GDP) for the first time. By 1996 it increased further to 25.5 percent, before falling back slightly to 25 percent in 1997. In the meantime, the share of agriculture in GDP declined steadily, from 29.7 pereent in 1976 to 24.3 percent in 1986, and further reduced to 16.5 percent in 1996.

Inflation rate



Source: IMF

Structure of the economy (% GDP)



Source: World Bank

• Economic performance

When the New Order was established, the economy was in a desperate state. Production and investment had fallen in many sectors since 1950, and real growth averaged only about 2 percent per year in 1950-65, less than the growth of the population. Manufacturing accounted for less than 10 percent of GDP and was characterised by substantial excess capacity caused by uncertainties about prices, supplies and government regulations. In the early 1960s budget deficits amounted to as much as 50 percent of total government expenditure, export earnings slumped and inflation accelerated to a peak of 640 percent in 1966.

In the mid-1960s, Indonesia's 'New Order' government under Suharto had regarded economic development as its prime objective. A reappraisal of economic objectives took place after the economy was rehabilitated; they were henceforth defined as stability, growth and equity, collectively described as the "trilogy of development". Backed by these policies, Indonesia recorded consistently high rates of economic growth, well in excess of the rate of population growth, for more than three decades. Between 1970-79, the average growth rate reached 7.8 percent. In the meantime, however, inflation was high with double-digit except three years, it averaged 17 percent per year. In fact inflation rose to 40.1 percent in 1974.

With its heavy dependence on the extractive sectors, however, the Indonesia economy is extremely vulnerable to developments in international commodity markets. From 1982 to 1986, the country faced a number of external shocks, including sharp decline in the price of oil and international exchange rates, which affected the terms of trade and the value of the country's external debt. Starting in 1983, the government responded with a remarkably comprehensive and successful adjustment programme. It devalued the rupiah in 1983 and 1986 and cut the expenditures, mainly by rescheduling capital-intensive projects. However, the adjustment was not painless. Growth initially fell due to lower export incomes and a tight 1983 budget. By 1985 the economy had slipped into a recession, with only 1 percent growth. Even so, the government pushed ahead with the adjustment process, which actually accelerated in 1986. Between 1980 and 1989, the growth rate averaged 5.8 percent per year. In the late half of the 1980s, perseverance paid off in a boom of manufactured exports that pushed the export growth rate to 25 percent a year for the period 1985-91. Since then Indonesia had chalked up average annual growth of about 7.3 percent for the period 1990-96. From a low-income country in the mid-1960s, Indonesia successfully transferred itself into a middle-income country with GDP per head of almost $1,120 in 1996. Between 1985 and 1997 the average annual rate of inflation held in single digits of 7.8 percent. However, the regional crisis slowed GDP growth to 4.6 percent in 1997, and economy further contracted by 13.7 percent for the whole of 1998, the worst recession in 35 years.

Main Economic Indicator (Indonesia)

	1980-89	1990-96	1991	1992	1993	1994	1995	1996	1997
Real GDP growth (%)	5.8	7.3	7.0	6.5	6.5	7.5	8.2	8.0	4.6
Inflation rate (%)	9.6	8.6	9.4	7.5	9.7	8.5	9.4	8.0	6.2
Cur. balance/GDP (%)	-2.4	-2.5	-3.3	-2.0	-1.3	-1.5	-3.5	-3.4	-2.7
Exports / GDP (%)	23.6	23.1	22.7	24.4	23.3	22.6	24.5	21.9	24.9
Imports / GDP (%)	15.5	19.4	20.2	19.6	17.9	18.1	21.9	18.9	19.4
Saving / GDP (%)	30.6	32.4	33.5	35.3	32.5	32.2	30.6	30.2	31.0
Ex rate (av. Rp/$)	1135	2123	1950	2230	2087	2161	2449	2342	2909
Population growth (%)	2.2	1.4	1.7	1.7	1.3	1.6	1.6	1.6	1.6

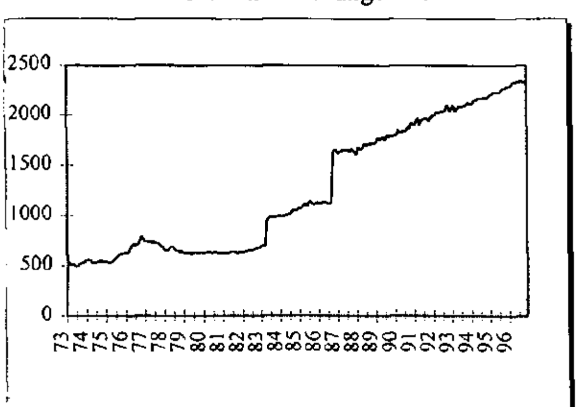
Sources: Asian Development Bank, Key indicators of developing Asian and Pacific countries 1998, 1999.

• Exchange rate series

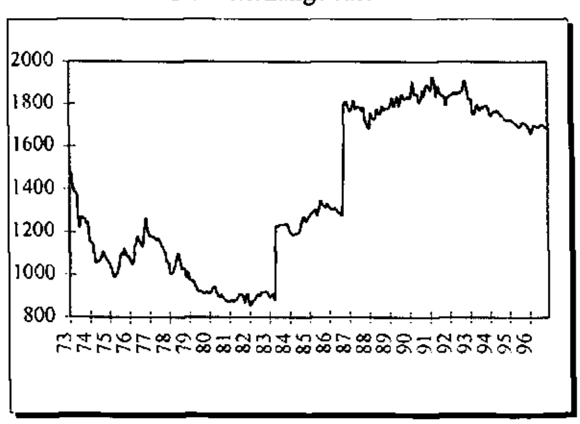
After a period from the early 1970s in which the rapiah was pegged to the dollar, the government introduced a managed float in November 1978, aimed at maintaining the competitiveness of Indonesia's non-oil/gas exports in the face of the inflation differential against its main international customers and competitors. Two major discrete devaluations of the rupiah against the US dollar were implemented in March 1983 (by 27 percent) and September 1986 (by 31 percent). The following period, from 1988 to 1996, was the one of remarkable stability in Indonesia's exchange rate, with steadily deprecation against the dollar. During this period, the rupiah's value against the dollar fell from Rp1733:$1 in 1988 to Rp2383:$1 in 1996, an average annual rate of deprecation of 4.1%. The Asian currency crisis forced the government to allow the rupiah to float freely on August 14th, 1997. From Rp2,450:$1 on the eve of the crisis at the end of June 1997, the rapiah hit lows of around Rp17,000:$1 in early January and mid-June 1998, about 85% below its pre-crisis level. From September 1998 the rapiah strengthened rapidly and stood at Rp7,490:$1 on November 26th.

From 1993 and on, the real exchange rate of the rupiah witnessed a slightly downward trend, suggesting that rapiah was generally appreciating against the US dollar.

Nominal exchange rate



Real exchange rate



2.2.2 Japan

• Background

Japan has a land area of 377,819 square km, and a population of 126.2 million (October 1997). Unlike other countries in our sample, it was already a relatively mature industrial economy at the beginning of the post-war period. At present, Japan's economy is the second largest of the OECD group. Until recent Asian financial crisis, it had also been one of the faster growing and was catching up with the USA as the major trading economy in the world. However, being lack of energy resource, the economy is overwhelmingly dependent on imported energy supplies.

• Political history

Until the mid-19th century Japan was a feudal society governed by military rules. The restoration of the authority of the Meiji emperor in 1868 was followed by the setting up of a parliamentary system, although with a very limited suffrage. During the US occupation (1945-52), after Japan's disastrous defeat in the Pacific War, a radical land reform programme was undertaken and the *zaibatsu* (business conglomerates) were nominally broken up. Under the guidance of the occupation authorisation the 1947 constitution, which reduced the emperor's status to merely a symbol of the state, was established. The major conservative party, the Liberal Demarcation Party (LDP), making up of powerful factions, was in government continuously from 1955 to 1993. Since the election in July 1993 there have been three different coalition governments. The most recent government was cobbled together in June 1994. In a short period from 1997, the coalition was made up of unlikely partnership of the major conservation and left-wing parties, under a socialist prime minister.

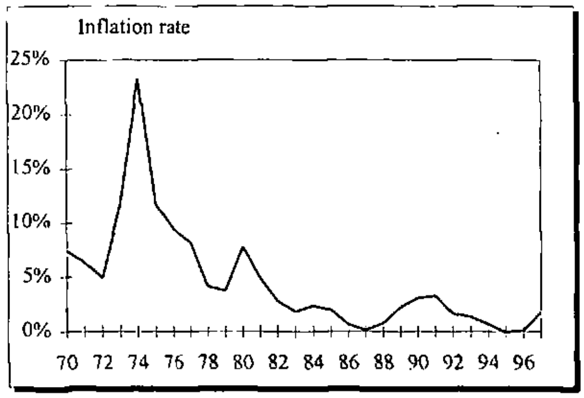
• Economic structure

During the first stages of Japan's modern industrialisation from the Meiji restoration in 1868 to defeat in the second world war in 1945, the textiles industry and heave industries were dominant. The government also played a leading role in developing industry, especially in the areas of railways and mining. Until the 1930s, however, most Japanese remained in the agricultural sector and only about 16 percent of the workforce was employed in manufacturing. Japan's industrial structure changed radically after the second world war. The 1950s brought the beginning of the "period of high growth", as the UN forces in the Korean war procured many of their supplies from Japan and thus stimulated the development of a truly modern industrial base. Manufacturing has been the mainstay of the Japanese economy since the 1960s. The electronics and car industries are famous for their success in international markets, although both have suffered in recent years from the strength of the yen, which has prompted a wave of outward direct investment into lower-cost countries.

More broadly the construction and pharmaceuticals industries expanded quickly in the post-war period, and the petrochemicals and electronics businesses also gained in importance. The iron and steel and shipbuilding industries were nurtured through a policy of export promotion under the patronage of Ministry of International Trade and Industry (MITI) and other government agencies. The strategy met with such success that impulse response subsequently rippled to companies that aimed to produce cars, precision machinery and optical equipment. The 1973 oil crisis presented a major challenge to all of Japan's enterprises. The government reaction was drastic and effective, and the country emerged in

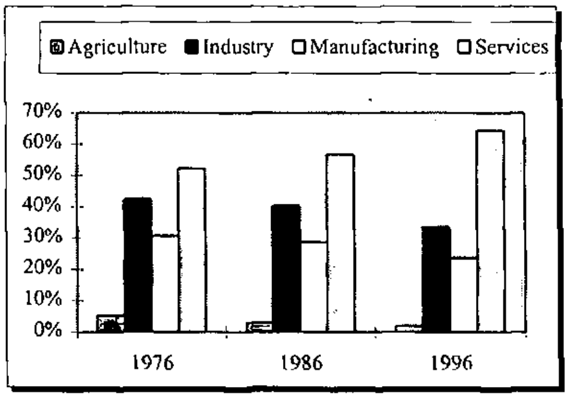
1975 and 1976 with a much higher degree of efficiency. By the second oil shock of 1979, however, Japan's heavy industry was already losing its competitiveness in international markets, and a shift of resources towards high-technology manufacturing gathered pace and the country built a presence in the most advanced produce markets.

Inflation rate



Source: IMF

Structure of the economy (% GDP)



Source: World Bank

• Economic performance

Until the recent financial crisis triggered in mid-1997, Japan's economic performance since the Second World War had been phenomenal. After the war, the economy was nearly devastated. Since then, the country started to recover and achieved high-level growth. The period from the end of war to 1955 was marked by post-war rehabilitation. Under the new constitution, the Japanese government launched a series of polities to liberate the nation from the economic plight left by the war. In the course of these developments, the economy continued to recover to the pre-war level, stimulated in part by special demand arising from the Korean war. The 1950s-1970s saw the highest growth rates, with real GDP growing at an average rate of 10 percent or greater each year. Although the first oil crisis triggered a fall in real GDP in 1974 of 1.2 percent, as well as a surge in inflation and a current account deficit, the economy quickly recovered thanks to tight monetary policy, cost cutting by the manufacturing sector and growth in non-traditional industries. Buoyed by these new strengths, Japan weathered the second oil crisis in 1979 relatively smoothly compared with other developed countries, although growth slowed considerably, averaging just 4 percent per year in 1980-85. In 1965 Japan's GDP was only 10 percent that of the USA, but in 1991 it amounted to 58.9 percent. Whereas the annual real GDP growth rate in period 1988-92 was 1.6 for the US economy, it was 4.2 percent in the case of Japan. The inflation rate was relatively high during the high growth period, it averaged 9.0 percent between 1970-80 and double-digit inflation occurred in 1973-75 (averaged 16 percent each year).

However, Japan's growth performance in the 1990s has been disappointing. After the peak in 1991, following 4-years still rapid pace between 1987-91, the economy went through an unusually long recession that lasted 3 years and then a very modest expansion, which ended in March 1997. The 1992-93 downturn was the deepest recession since the first oil crisis, which brought the real GDP growth rate down to only 1.1 percent in 1992 and almost zero percent in 1993. The slowdown was driven by important restructuring in the corporate sector as a result of declining profitability and competitiveness pressure associated with a sharp appreciation of the yen, reflecting the collapse of Japan's "bubble" economy, based on rising land and share prices in the late 1980s. Despite large injections of public spending in 1994 and 1995, these years brought only a mild recovery. GDP grew by just 0.6 percent and 1.5 percent respectively in real term. As a result of this the government adopted even more aggressive fiscal stimuli which, with the help of a depreciating yen, brought the rate of real growth in 1996 up to 4.1 percent. However, hit by the recent financial crisis, the real growth rate were 0.8 in 1997 and contracted 2.6 percent in 1998.

However, one prominent feature of the Japanese economy is its favourable inflation performance in recent years, largely due to the Japan's monetary policy which evolved from a system implemented through credit controls in association with the regulation of interest rates, to a system geared more towards medium-term monetary control with market-determined interest rates. These policy changes contributed to apparent successes in achieving price-level stability. The data from IMF indicate that Japan has been one of the lowest inflation countries since the early 1980s. The average annual inflation rate for the period 1981-96, measured by the changes of the consumer price index, was 1.7 percent, which is lower than 4.1 percent experienced by the US.

Main economic indicator (Japan)

	1980-89	1990-96	1991	1992	1993	1994	1995	1996	1997
Real GDP growth (%)	**4.0**	**2.2**	**3.8**	**1.0**	**0.3**	**0.6**	**1.5**	**3.9**	**0.8**
CPI Inflation (%)	**2.5**	**1.4**	**3.3**	**1.6**	**1.3**	**0.7**	**-0.1**	**0.1**	**1.8**
Cur. balance / GDP (%)	**2.4**	**2.3**	**2.0**	**3.0**	**3.1**	**2.8**	**2.1**	**1.4**	**2.3**
Exports / GDP (%)	**12.2**	**10.7**	**9.9**	**9.3**	**8.4**	**8.7**	**7.9**	**8.4**	**9.4**
Imports / GDP (%)	**10.0**	**8.3**	**7.5**	**6.4**	**5.6**	**6.0**	**6.0**	**7.1**	**7.5**
Gross Saving / GDP (%)	**31.7**	**32.6**	**34.5**	**33.9**	**32.7**	**31.3**	**30.8**	**31.7**	**31.1**
Ex rate (av.; ¥/$)	**182.5**	**134.9**	**134.5**	**127.6**	**111.2**	**102.2**	**94.1**	**108.0**	**121.0**
Population growth	**0.6**	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.5**	**0.2**

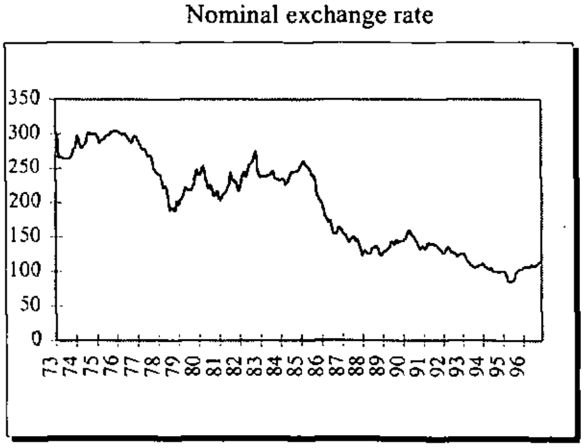
Sources: OECD Economic Outlook.

• Exchange rate series

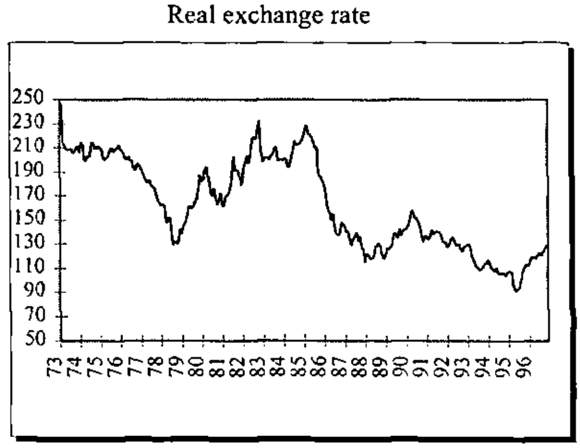
After Japan adopted the floating rate in 1973, the nominal value of the yen had steadily appreciated vis-à-vis the US dollar. In 1973, approximately 300 yen was needed to buy one US dollar. By 1995, the yen was trading at around 94 yen per US dollar. Between 1990 and 1995, the yen appreciated against the dollar from an average of 144.8 per dollar to 94.1 per dollar. In 1996 and 1997, however, the yen weakened to average rates of 108.8 and 121 per dollar respectively.

While the inflation rates of the two countries remained roughly comparable, the yen had appreciated in real terms, especially in the CPI-based real exchange rate. Between 1973-96, the average appreciation of the real exchange rate was 1.92 per year. Moreover, the Japanese yen's real appreciation against the US dollar was by far the most persistent, except for two brief periods of slight depreciation between mid-1978 to mid-1982 and between 1989 to 1990. It can be observed that the yen/dollar exchange rate was the least volatile among the seven currencies in this study. The consistent appreciation of Japan's real exchange rate suggests that the fundamental factors play important roles.

Nominal exchange rate



Real exchange rate



2.2.3 South Korea

• Background

South Korea has a land area of 99,313 square km and a population of 46 million (mid-1997 estimate). Until the recent economic crisis in East Asia, the performance of Korea's economy had been remarkable for more than three decades. Over this period the country built a fundamentally strong economy with enormous human and capital resources, and technological capacity. Its manufacturing development, export growth, macroeconomic stability and poverty reduction were the envy of other countries. Due to the extraordinary growth, Korea transformed itself from one of the poorest nations in the world to the 11th largest economy and exporting country. However, Korea is poorly endowed with natural resources. It has no onshore oil or natural gas, and none of which has been found offshore either. For this reason, the economy is dependent on imported petroleum.

• Political history

Korea as a nation processes two attributes: almost total ethnic homogeneity, and a very long history. A recognisably Korea cultural identity has existed on the peninsular for at least 2000 years (most nationalist historiography claims 5000 years). As ancient civilisation which had enjoyed many centuries of unity and political independence, Korea was unable to preserve that independence in the ear of colonialism, coming under Japanese rule effectively in 1905 and formally in 1910. Japan's colonial rule was harsh and culminated, in the decades to 1945, in an attempt to wipe out Korean identity by imposing the Japanese religion, language and names. The years between 1945 and 1953 were a period of extreme disarray for Korea. Following Japan's defeat in the Second World War, the country was partitioned. After the failure to re-unite the country in 1948, the Republic of Korea (S. Korea) was proclaimed, and democratic elections were held. In 1950 the Korean war began and ended in 1953, which destroyed over 40 percent of industrial facilities and almost one million were killed.

For most of its history South Korea had been ruled by a succession of authoritarian regimes, civilian in the case of Syngman Rhee (present in 1948-60), and military in the cases of Park Chung-hee (1961-79) and Chun Doo-hwan (1980-88). Although Roh Tae-woo (1989-93) was the military nominee of his predecessor, he was elected president in 1988 in a relatively fair and free election. South Korea passed a milestone in its political history when he handed over power in 1993 to an elected civilian successor, Kim Young-sam, following an election in December 1992. A further milestone, the transfer of power by an elected president to a successful opposition candidate, was passed with the assumption of office by Kim Dae-jung, who is the first Korean president without a military background, in February 1998. The influence of the military, which for long tended to view opposition to the government as disloyalty to the regime, is no longer paramount.

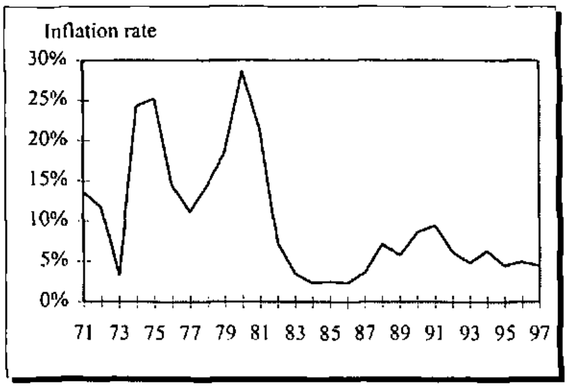
• Economic structure

After experienced dramatic growth rates in the last three decades, the changing structure of Korea, from its traditional agrarian to the industrialised economy, is obvious. In 1960, 40 percent of the Korean domestic GDP consisted of agricultural products, while industrial output was only 19 percent of GDP[6]. By 1976, the relative proportions of agricultural and industrial output were reversed; the agricultural sector accounted for only 23.5 percent while

[6] The World bank 1978, p.80.

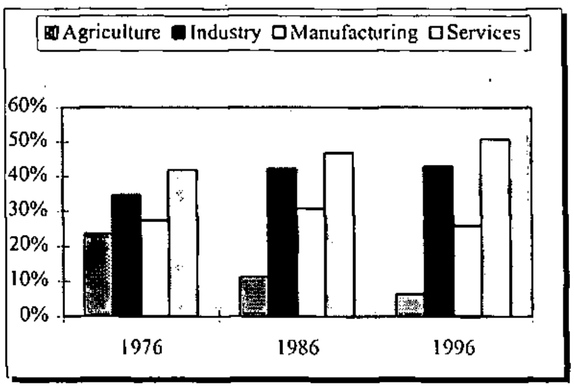
the industrial sector was responsible for 34.6 percent of GDP. The share of agriculture in GDP further declined to 11.2 percent in 1986, and reached to only 6.3 percent in 1996. In the meantime, the share of manufacturing in GDP increased steadily, from 27.4 percent in 1976 to 30.8 percent in 1987 before declining somewhat to 25.9 percent in 1996. There was also a significant shift in the composition of manufacturing output. Heavy industry, which includes chemicals, iron and steel, metals, machinery and transportation equipment, comprise major part of share of manufacturing output at present day.

Inflation rate



Source: IMF

Structure of the economy (% GDP)



Source: World Bank

• Economic performance

Following the end of the war was the reconstruction period (1953-61), and the GNP growth of 4 to 5 percent was realised during this period.[7] However, the sustained economic take-off did not occur before a government firmly committed to economic development which had been established in 1961. During 1971-79, the average annual GDP growth rate of 9.4 percent was one of the highest in the world. Indeed, during the most rapid growth period

[7] See OECD Economic Surveys, Korea, 1994.

inflation was very high, which soared to double-digit between 1971-81 with the annual increase in the CPI averaged 17 percent.

In 1979 Korea encountered a variety of problems that threatened to undercut the 1970s impressive growth. Rising oil prices battered Korea's terms of trade, the world recession dampened export demand, and high interest rates boosted debt service costs. In 1980, output fell 5 percent, and inflation soared to more than 29 percent, and the current account deficit approached 9 percent of GDP. Korea responded quickly to its troubles with an aggressive January 1980 stabilisation package backed by International Monetary Fund standby credits. The government ended the fixed exchange rate regime, devalued the won by 17 percent, and tightened monetary and fiscal policy. Within two years, the stabilisation policies adopted in 1980 had reduced inflation to 7.2 percent in 1982 and 3.4 percent in 1983. The governments' prompt and effective response to a potential crisis strengthened the economy, preparing it for rapid growth in the 1980s.

Main Economic Indicator (Korea)

	1980-89	1990-96	1991	1992	1993	1994	1995	1996	1997
Real GDP growth (%)	8.2	7.5	8.2	5.1	5.8	8.6	8.9	7.1	5.5
CPI Inflation (%)	8.4	6.4	9.4	6.1	4.8	6.3	4.4	4.9	4.4
Cur. balance/GDP (%)	-0.1	-1.7	-2.8	-1.2	0.3	-1.0	-1.9	-4.7	-1.9
Exports / GDP (%)	31.0	25.6	24.4	24.9	24.7	25.2	27.4	26.7	30.8
Imports / GDP (%)	32.0	27.8	27.7	26.6	25.2	26.9	29.6	31.0	32.7
Gross saving / GDP (%)	31.4	35.9	36.4	35.2	35.4	35.7	36.8	35.5	35.2
Ex rate (av.; W/$)	757.8	771.9	733.4	780.7	802.7	803.5	771.3	804.5	951.1
Population growth (%)	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

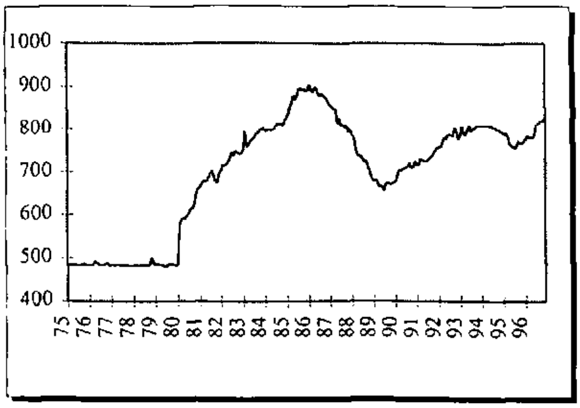
Sources: Asian Development Bank, Key indicators of developing Asian and Pacific countries 1998, 1999.

In the 1980s, inflation was under control, and the average growth reached 8.2 percent between 1980-89. In 1989 and 1990, the government reduced its budget surplus by stepping up spending on infrastructure and housing, thus reversing a slight slowdown that had occurred in economic growth in 1992 and 1993. Between 1990 and 1996, the economy expanded at about 7.5 percent a year. GDP per capita exceeded US$11,000 in 1996. In the same period, Korea maintained a budget surplus in all but two years and inflation remained in the single-digit range, with average rate being 6.4 percent. However, the regional financial crisis slowed the growth rate to 5.5 percent in 1997, and followed by a sharp contraction by 5.5 percent in 1988.

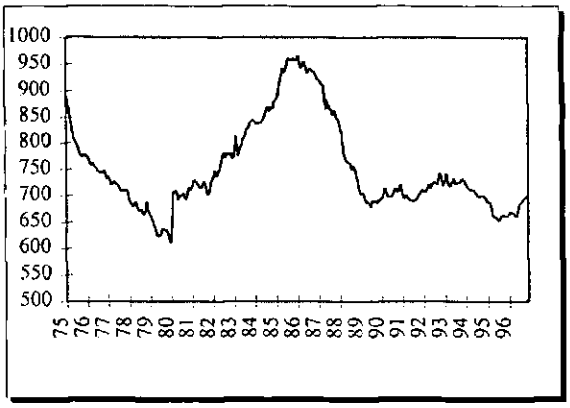
• Exchange rate series

Korea maintained a fixed exchange rate against the dollar in the late 1970s. As the inflation was higher at home than abroad, the won became progressively more overvalued in real terms, and exports suffered as a result. In 1980 the government enacted an important and need programme of macroeconomic stabilisation and microeconomics reform. In the same year, the won devalued by 17 percent. This devaluation, together with the tighter monetary and fiscal policy, succeeded in stimulating rapid export growth, reducing the current account deficit, and stabilising the economy. In 1980, the government ended the fixed exchange rate regime and adopted the floating one.

Nominal exchange rate



Real exchange rate



Korea used exchange rate protection when it ran a current account surplus/deficit. While the desire to protect export industries was certainly a factor, the main concern was to reduce the debt ratio and to build up reserves to avoid repeating the close brush with a foreign debt crisis in 1984-85. The Korean won persistently depreciated against the US dollar in 1980-1986 due to the current account deficit, and then appreciated sharply during the next three years when it ran a current account surplus in 1986-1989. The movements in exchange rate were relatively stable in the subsequent years. However, hit by regional crisis, the won had fallen to around W1480:$1 by mid-December 1997, representing a depreciation in nominal terms of more than 40% since the beginning of the year. By December 1998, the won recovered to around W1200:$1.

As far as the real exchange rate is concerned, it depreciated from 1980-85, then appreciated from 1986-89 before fluctuating around 650-750 won per US dollar in the following years.

2.2.4 Malaysia

• Background

Malaysia is a country with a territory of 329,758 square km and a population of 21.8 million (mid-1997 estimate). Over the past decade until the recent financial crisis, the economy witnessed fast GDP growth and low inflation. Accompanied by the fast growth are the dramatic reduction of poverty, the great increase of female literacy and the reduction of income inequality. In 1996 GDP per capita had increased to US$4,650. Malaysia is well endowed with mineral and agriculture resource. It has good infrastructure in the urban as well as in the rural area. For a long time the country has enjoyed political and economic stability.

• Political history

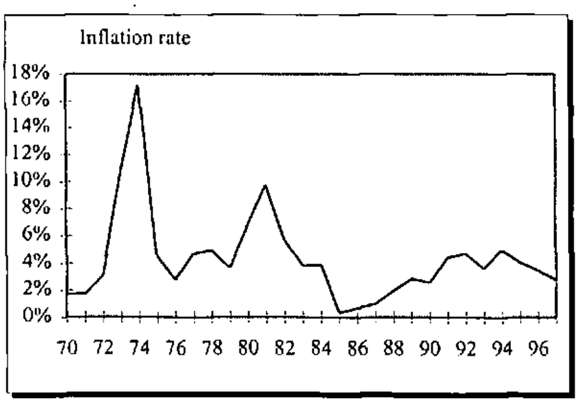
Malaysia is a federal, constitutional monarchy within the Commonwealth. After ruled by Japanese, who occupied the country from 1941 to 1945, the country proclaimed full independence for the 11 peninsular states in 1957. When the peninsula-based federation was expanded to form Malaysia in 1963, the two former British-ruled areas in northern Borneo, Sarawak and Sabah, were included along with Singapore which withdrew from the federation in 1965.

In Malaysia, there are racial and cultural diversity, where Malays account for around 58 percent of population, the ethnic Chinese 25 percent and India 7 percent. Long from the history to present day, racial and cultural diversity have benefited the economy of the peninsula but also have given rise to intercommunal tensions. Following a fiercely fought general election in 1969, Malaysia suffered serious riots between Malays and Chinese, in which many were killed. In the political crisis that followed, a broader-based coalition, the Barisan Nasional (BN) was emerged. With some minor changes in the composition of the BN, the coalition has ruled the country ever since.

• Economic structure

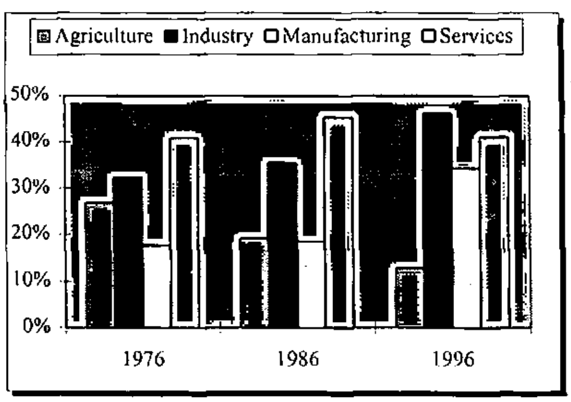
In the last 20 years Malaysia has industrialised rapidly. It has been transformed from a country which depended for its prosperity and economic resilience on producing a wide range of mineral and agriculture export commodities into an economy dominated by manufacturing industries. While the output in the agricultural, forestry and fisheries sectors taken together has sustained an annual growth rate of around 2.5 percent in recent years, the relative importance of these rural-based sectors within the economy as a whole has declined because of the rapid growth of the industrial and services sectors. The agriculture was historically the largest contributor to GDP, until overtaken by manufacturing in 1987. In 1976 the shares of agriculture and manufacturing accounted for 26.8 and 17.7 percent of GDP respectively, while in 1986 they accounted for roughly equal proportions of GDP. Then by 1996 manufacturing was nearly three times as important as agriculture. Since 1987, manufacturing has become the single largest component of GDP and by for the largest generator of export earnings.

Inflation rate



Source: IMF

Structure of the economy (% GDP)



Source: World Bank

• Economic performance

For the three decades since independence in 1965, Malaysia continued the essentially free market trade and industrial policies of the colonial government. During the 1970s, the Malaysian economy was growing by a steady 8.1 percent at an annual rate, mostly as a result of the world demand for its rubber, tin and other commodities. However, the country suffered a brief recession in the mid-1980s, largely because of the slump in commodity prices in the world markets. The economy actually shrank by 1 percent in 1985 and grew by 1 percent in 1986. Following the recession, the economy had again picked up and enjoyed consistent fast growth. The main driving force of economic development has been investment in export-oriented manufacturing and the gross export earnings these industries generated. Malaysia's economic performance has been very strong over the past decade. Real GDP grew at nearly 9 percent, and inflation had been kept below 4 percent. These achievements can be attributed to Malaysia's traditionally strong fiscal policy over the years, the prudent management of the country's external exposure, and well developed supervisory and regulatory framework for the financial sector. In 1997 when Asian financial crisis started the growth rate still reached 7.7 percent. However, it was severely affected in the following year. Real GDP contracted by 6.2 percent in 1998 as output of all major sectors of the economy declined.

Main Economic Indicator (Malaysia)

	1980-89	1990-96	1991	1992	1993	1994	1995	1996	1997
Real GDP growth (%)	5.8	8.8	8.6	7.8	8.3	9.3	9.4	8.6	7.7
CPI Inflation (%)	3.7	4.0	4.4	4.7	3.6	4.9	4.0	3.5	2.7
Cur. balance/GDP (%)	-3.0	-6.0	-8.8	-3.8	-4.8	-7.8	-10.0	-4.9	-4.8
Exports / GDP (%)	52.2	75.4	71.4	69.8	73.4	80.9	84.6	78.9	79.9
Imports / GDP (%)	44.7	76.2	76.2	68.3	71.1	81.9	88.9	79.0	79.8
Dross saving / GDP (%)	33.1	37.4	33.5	36.5	37.7	38.8	39.5	42.6	44.4
Ex rate (av.; M$/$)	2.44	2.60	2.75	2.55	2.57	2.62	2.50	2.52	2.81
Population growth (%)	2.6	2.9	4.4	2.6	2.7	2.8	2.9	2.3	2.5

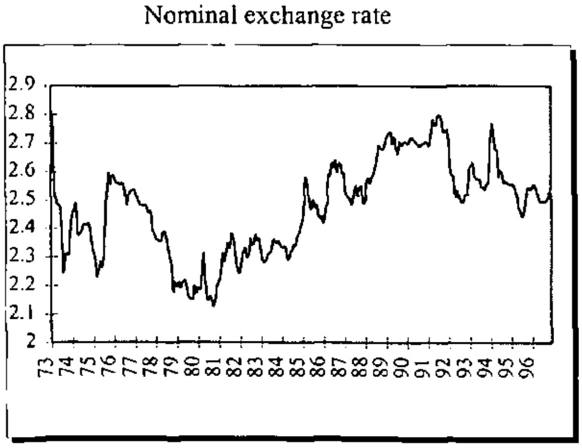
Sources: Asian Development Bank, Key indicators of developing Asian and Pacific countries 1998, 1999.

• Exchange rate series

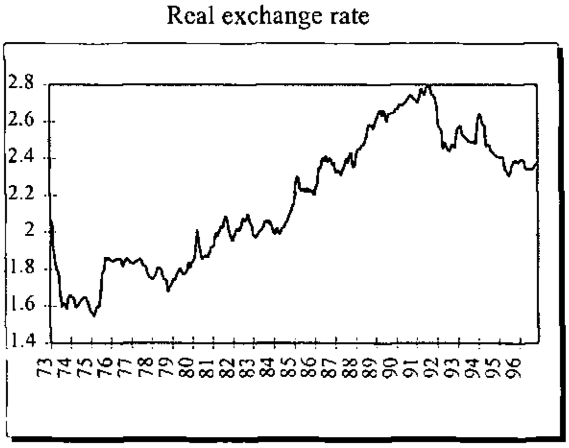
Since 1975 the ringgit has been pegged to a basket of currencies of the country's major trading partners. The exchange rate is monitored by the central bank. In spite of this basket, however, the policy in the early 1980s was to track the US and Singapore dollars fairly closely. The decision to float freely from these currencies was taken in 1984 and was a major factor in the subsequent sharp depreciation of the exchange rate. In 1980-91, the ringgit persistently depreciated against the US dollar, depreciating by around 25 percent over this period (M$2.1/US$1 to M$2.8/US$1). During 1993-94 there were wide fluctuations in the value of the currency, a strong rise followed by a sharp fall. The ringgit tumbled heavily from mid-1997 as investor's confidence in the region's economies was undermined, triggered by the floating of the Thai baht. At M$2.525/US$1 when the crisis erupted in July 1997, the ringgit breached to M$4/US$1 barrier on January 5th 1998, and fell to M$4.6/US$1 later that month before staging a modest recovery in the ensuing weeks.

Since the beginning of 1992, the ringgit had been strengthening against the US dollar in the real term, with a 16.7 percent (from M$2.8/US$1 in 1992 to M$2.4/US$1 in 1996) appreciation.

Nominal exchange rate



Real exchange rate



2.2.5 The Philippines

• Background

The Philippines is a country with a land area of 300,176 square km and a population of 73.53 million (mid-1997 estimate). It is well endowed with natural and human resources. Before the recent financial crisis, it had shown signs of economic recovery resulting from greater confidence in its economic and political future, as manifested in the increased inflow of foreign capital. The steady economic growth since the mid-1980s has quite markedly reduced the incidence of poverty.

• Political history

After invaded by Japanese in 1941, the Philippines was made full independence in 1946. The newly independent republic initially maintained preferential economic relations with the US and new republic had a constitution modelled on that of the US, with an executive president, a bicameral Congress and a Supreme Court which can rule on the constitutionality of government actions. The fairly peaceful alternation in power within the political elite was interrupted in September 1972 as the president, Ferdinand Marcos, neared the end of his second term. Citing the threat from "subversive forces", the president imposed martial law.

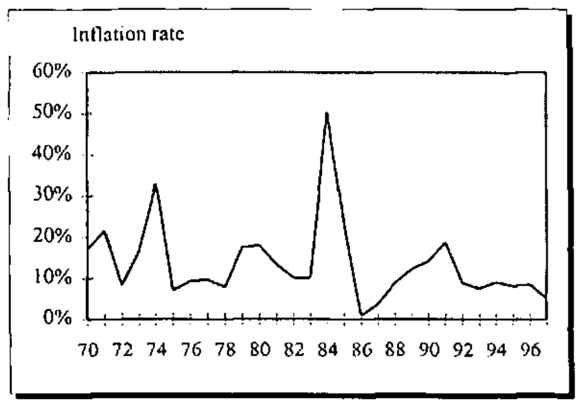
For the next 13 years, until 1986, the Philippines experienced "constitutional authoritarianism". In a series of elections the president and his party consistently recorded overwhelming popular support, whether or not the opposition participated in the exercise. The situation changed radically in August 1983, when Benigno Aquino, the opposition leader regarded as the most credible alternative to Mr Marcos, was assassinated. A series of massive demonstrations followed in which the disenchantment of the urban middle class, and notably the business community, was expressed for the first time. To reassert his own supremacy, Marcos called an early presidential election for February 1986. In a close-run battle he was narrowly defeated by the candidate, Corazon Aquino, the widow of Benigno Aquino. Marcos was forced into exile under domestic and external pressures.

Under the new regime civil liberties were restored. A new constitution, drawn up by a convention appointed by Aquino, largely restored the set-up abolished by Marcos in 1972 but with new controls on the presidency based on the experience of the Marcos years. However, the new administration's path was not easy. From July 1986 there was a series of attempted coups and rumours of coups, more or less credible, in which elements of the military were involved. In all cases the loyalty of then chief-of-staff, General Ramos, was critical. In the 1992 election Ramos took the power which marked the political stability in the Philippines.

• Economic structure

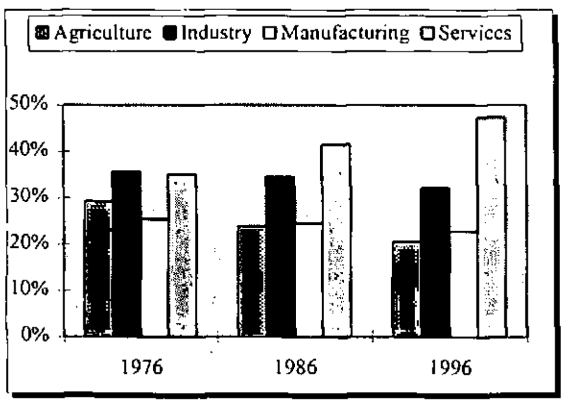
The manufacturing sector is the single most important production sector in the economy. The sector developed rapidly during the 1950s and 1960s essentially for import substitution, aided by high levels of protection for domestic industry. There was marked growth in industries assembling consumer goods, which were initially heavily dependent on imported components. In response to the second oil shock and the less favourable external environment, the government launched a programme in the early 1980s to develop the country's intermediate and heavy industrial base by means of a number of industrial projects in which it was prepared to participate.

Inflation rate



Source: IMF

Structure of the economy (% GDP)



Source: World Bank

In the Philippines, although manufacturing contributes more to GDP, agriculture is also important, which is dominated by two crops - rice and coconuts. However, the contribution to GDP of agriculture has been declined steadily for the last decades, from 29.3 percent in 1976 to 23.9 percent in 1986, and 20.6 percent in 1996. The contribution to GDP of manufacturing has been around 25 percent.

• Economic performance

During the 1970s, the growth rate was high, with 6.3 percent on average between 1970-79. However, there was a notable exception in the mid 1980s. During this period, the country experienced severe political unrest, and the economy had contracted 5.8 percent in 1984 and 4.7 percent in 1985. The real GDP growth declined to 2.2 percent in the annual average rate between 1980-89. Inflation soared to double digit of 20.3 percent during the period 1979-85.

The start of the stabilisation process in both the economic and political areas in the Philippines can be attributed to the Aquino and Ramos administrations. From 1986 the economy showed steadily recovery as the result of the policies of profound restructuring and liberalisation perused by the government. Although there were short time decline in 1991-92, the country had recorded a period of sustained and strengthening growth in GDP since 1993. Based on the buoyant export markets stimulated investment, the economy had shown a remarkable recovery with the rate of GDP growth doubled to 4.4 percent in 1994 and registered a further small improvement to 4.8 percent in 1995, when the outturn was depressed by drought. GDP growth accelerated to 5.7 percent in 1996 before moderating to 5.1 percent in 1997 owing to financial tightening in the contest of a worsening financial crisis and a lower rate of growth of exports of goods and services. The recovery in economic performance since 1992 has been accompanied by a steadying in the rate of consumer price inflation. Between 1992 and 1996 the average rate of inflation was 8.4 percent. It further went down to 5.0 percent in 1997.

Main Economic Indicator (Philippines)

	1980-89	1990-96	1991	1992	1993	1994	1995	1996	1997
Real GDP growth (%)	2.0	2.7	-0.7	0.6	2.1	4.4	4.8	5.8	5.2
CPI Inflation (%)	15.0	10.7	18.7	8.9	7.6	9.1	8.1	8.4	5.0
Cur.balance / GDP (%)	-2.6	-4.1	-1.9	-1.6	-5.5	-4.6	-4.4	-4.7	-5.2
Exports / GDP (%)	15.2	20.9	19.5	18.5	20.9	21.1	23.5	24.5	30.6
Imports / GDP (%)	20.1	33.8	28.3	29.2	34.5	35.4	38.4	41.4	46.8
Gross saving / GDP (%)	20.5	15.6	16.6	14.9	13.8	14.9	14.6	15.6	15.5
Ex rate (av.; P/$)	15.42	26.12	27.48	25.51	27.12	26.47	25.72	26.22	29.47
Population growth (%)	2.5	2.6	2.7	2.5	2.6	2.4	2.5	2.3	2.2

Sources: Asian Development Bank, Key indicators of developing Asian and Pacific countries 1998, 1999.

However, the Philippines' strong gains in growth and poverty reduction achieved over the last few years are being threatened by the dual impact of the regional financial crisis and weather shocks. Although the Philippines managed to survive the economic storm and has fared better than many of its neighbours, the effects of the crisis are being felt and the economy contracted by 0.5 percent in 1998. Inflation averaged 9.7 percent for the year.

• Exchange rate series

Prior to 1970, the peso had been fixed to the dollar. During the 1970s, the Philippines effectively implemented a fixed exchange rate policy vis-à-vis the US dollar.[8] However, the peg was not backed by appropriate supporting policies,[9] as an inward-looking strategy was pursued that combined a tightening of trade policies with, at the end of the decade, an easing of macroeconomic policies. This led to domestic prices rising significantly faster than those of its trading partners, causing a steady erosion of Philippine competitiveness and a stagnation in exports, and culminating in the debt crisis of 1983.

With foreign exchange reserves depleted and external commercial financing cut off, the government implemented two discretionary devaluations in October 1983 (by 27 percent) and June 1984 (by 29 percent) to induce a greater inflow of foreign earnings. However, since the US dollar -to which the peso was pegged -experienced considerable appreciation during this period, these adjustments had only a limited impact on the Philippines' economy. Confronted by a binding balance of payments constraint, the Philippines moved to a flexible exchange rate regime in 1984. This shift to a flexible regime, together with the adoption of far-reaching reforms, particularly in the trade and fiscal areas, was crucial to restoring external viability and laid the foundation for sustained

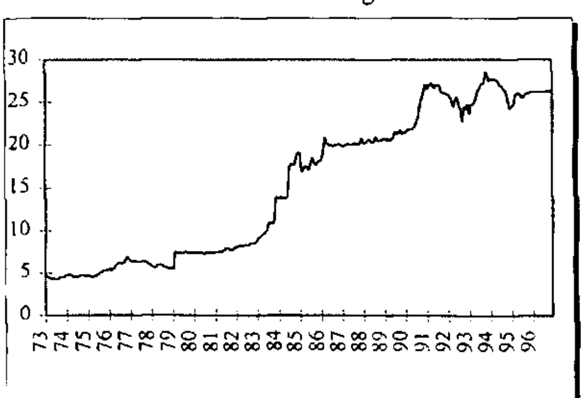
[8] Although a managed float was formally introduced in 1970, for all intents and purposes, exchange rate policy retained an objective of stability against the dollar, with changes in this bilateral rate averaging less than 2 percent per year during 1971-80.

[9] Dohner and Intal (1989) elaborate on these policies and their effects.

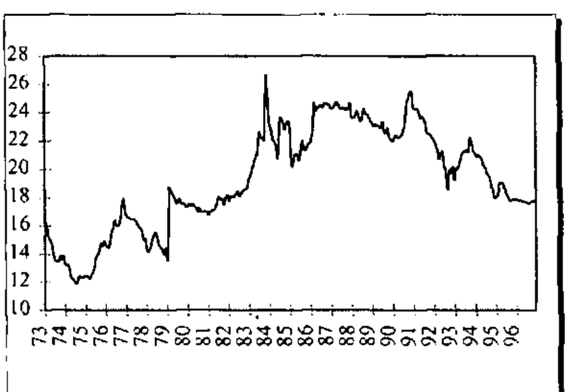
growth that had taken hold in recent years. From 1985 to 1990, the nominal rate remained broadly constant, with the peso/dollar rate ranging between 20 to 22. However, since 1991, the peso was characterised with high volatility, twice exhibiting rapid depreciation, and then appreciation, though short-lived. Hit by 1997 Asian currency crisis, the peso had been sharply depreciated and by the end of 1997 the rate was P39.98/$1, 51.1 percent lower than the end-June figure. Since January 1998 the peso has appreciated moderately and by March 27th 1988 the peso stood at P37.27/$1.

The real value of the peso exhibited considerable turbulence. However, despite this volatility, it appears a clear downward trend in the real value from 1986, which means that the peso had been on an appreciating path. During 1986-96, the real rate appreciated approximately 36 percent, although there were brief depreciations at the time.

Nominal exchange rate



Real exchange rate



2.2.6 Singapore

• Background

Singapore is a very small country with the land area being 647.5 square km and a population of 3.1 million (mid-year 1997 estimate, resident population only). In the year leading up to the 1997 regional economic crisis, the growth and development in Singapore was evident. Because of the sustained growth over the last decades, Singapore joined the ranks of newly industrialised countries, with GDP per capita being almost $32,000 in 1996. Singapore's economic strength is based on its superior infrastructure, efficient bureaucracy, political stability and sound macroeconomic fundamentals. However, being a small country without natural resources, the country is exceptionally dependent on foreign trade. It is, therefore, highly vulnerable to changes in external conditions.

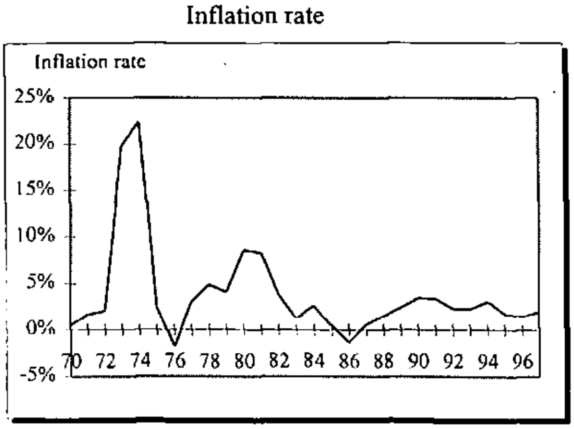
• Political history

It is a parliamentary democracy, led by the ruling People's Action Party (PAP). After being a UK colony, Singapore briefly became part of the Federation of Malaya, Sarawak and Borneo in 1963, but achieved full independence in 1965. Since then, the PAP, guided by the ideas of Lee Kuan Yew, the prime minister from 1959 to 1990, has dominated politics in Singapore. The success of the PAP has been built on a combination of rapid economic growth and the maintenance of a weak and divided opposition. In 1990, Mr Lee was replaced as prime minister by Goh Choh Tong who is supposed to be more liberal.

• Economic structure

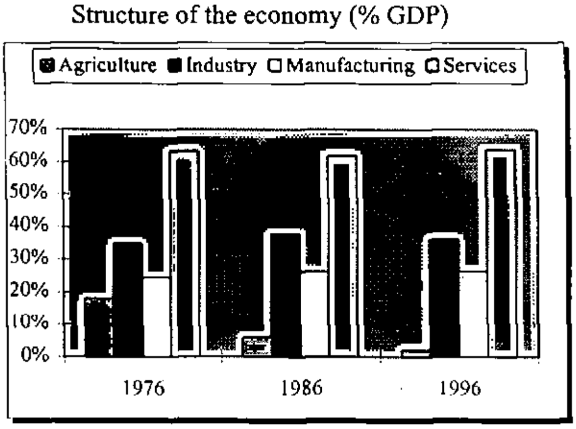
Singapore has a highly industrialised economy, and agriculture and mining are of only minimal important. At the time of independence, Singapore's industrial sector consisted of basic consumer electrical assembly, oil refining and some shipping facilities. In 1967 Texas Instruments set up a semiconductor plant, and other electronics firms quickly followed suit. There was also a massive expansion in oil refining in the late 1960s and early 1970s. In the 1980s the first computer disk-drive plant was established, and Singapore became the world leading producer of these products. During the same period, the petrochemicals industry was also developed further, and a number of new sectors, notably pharmaceuticals, assumed some prominence. In the 1990s, electronics has reasserted itself as the most important industry, which accounted for 50 percent of manufacturing output in 1997, although the downturn in demand for the output of this industry in 1996, and then again in 1998, and subsequent faltering of overall economic growth, has illustrated that a wider manufacturing base may be preferable.

Inflation rate



Source: IMF

Structure of the economy (% GDP)



Source: World Bank

• Economic performance

The most important feature exhibited by the Singapore economy is that the growth had been sustained at high levels until the recent financial crisis. Between 1970 to 1979 the growth rate reached 9.1 percent annual average, and the inflation rate was very low except for two years in 1973-74 which experienced double digit rate of 20 and 22 percent respectively. Singapore escaped the 1980-81 world recession with scarcely a dip in its robust growth. But in 1985 the economy encountered a sudden severe recession: growth fell from 8.3 percent in 1984 to -1.6 percent in 1985. Reasons for this unusual episode included government encouragement of high wages between 1979 and 1981, which was intended to speed the decline of labour-intensive production but backfired by eroding competitiveness, and the appreciation of the Singapore dollar's trade-weighted exchange rate. There were exacerbated by a sharp decline in public investment due to the simultaneous completion of several major projects. Private investment, which has been declining for several years, also dropped in 1985, apparently because of falling external demand resulting from Singapore's declining competitiveness. Recognising the problems, the government devised an integrated policy package that reversed the high wage policy to restore Singapore's competitiveness and stimulated domestic demand. These policy responses and a fortuitous depreciation in the Singapore dollar, due to the global depreciation of the US dollar, contributed to a rapid recovery. In 1986, growth recovered to 2 percent, and by 1987 it reached 9.4 percent. During the period 1980-89, the average growth rate was 7.3 percent.

The high growth level maintained through the 1990s. It reached 10.5 percent in 1994, falling to 8.7 in 1995. Growth in 1996 slowed further, to 6.9 percent, largely because of problems in the electronics sector, on which it is so dependent. Although growth picked up to 7.9 percent in 1997, the economy was hit in the Asian crisis to a lesser extent, compared with other countries in the region. Real GDP grew only 1.5 percent in the year. Despite the high growth rate during the 1990s, however, the rate of consumer price inflation was generally kept in the 1-3 percent range, the average inflation rate being 2.4 percent over the period from 1990 to 1996.

Main Economic Indicator (Singapore)

	1980-89	1990-96	1991	1992	1993	1994	1995	1996	1997
Real GDP growth (%)	7.3	8.3	7.0	6.4	12.0	11.3	8.7	7.8	6.8
CPI Inflation (%)	2.8	2.5	3.4	2.3	2.3	3.0	1.7	1.4	2.0
Cur.balance / GDP (%)	-2.7	12.3	10.8	11.3	7.8	16.5	16.0	14.9	15.2
Exports / GDP (%)	126.1	134.3	135.6	127.7	126.7	136.1	138.8	134.8	129.8
Imports / GDP (%)	153.0	147.9	152.0	145.2	145.9	144.5	146.1	139.3	137.5
Gross saving / GDP (%)	38.3	47.6	46.5	46.7	46.7	48.1	50.4	49.3	50.0
Ex rate (av.; S$/US$)	2.11	1.59	1.73	1.63	1.62	1.53	1.42	1.41	1.48
Population growth (%)	1.7	2.0	1.8	2.2	1.8	2.1	-2.0	5.9	2.0

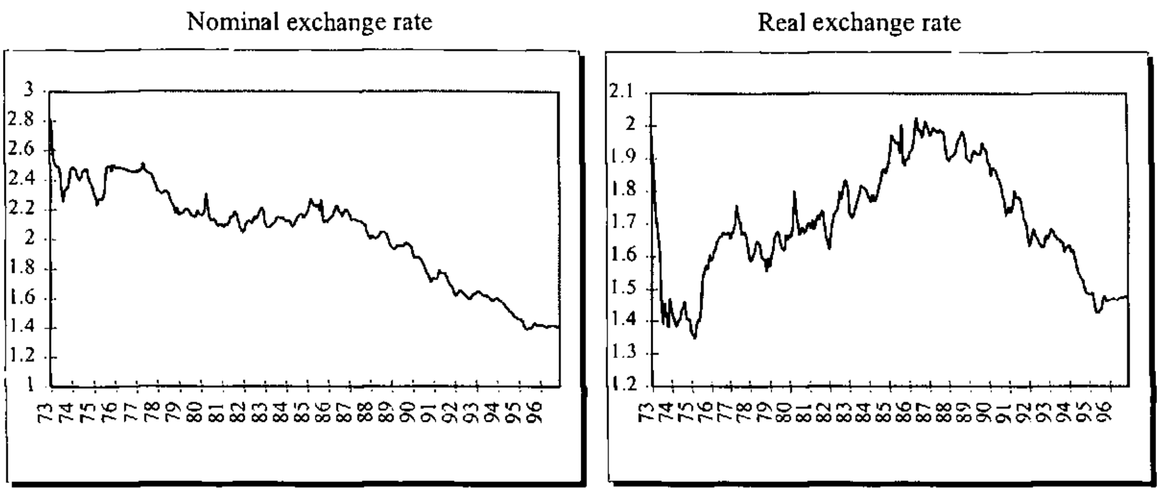
Sources: Asian Development Bank, Key indicators of developing Asian and Pacific countries 1998, 1999.

• Exchange rate series

The most obvious characteristic of the Singapore dollar is the sustained appreciation against the US dollar. In 1973 the nominal rate was traded at 2.8 per US dollar and by 1996, only 1.4 Singapore dollars were needed to buy one US dollar. Between 1973-96, the Singapore dollar appreciated against the US dollar by more than 2 percent per year, the strongest appreciation among Asia's fast growing economies. In Singapore, monetary policy has been explicitly framed in terms of the exchange rate since 1981 and has been targeted explicitly at a price-level objective. Consequently, exchange rate policy was almost completely passive during the period of US dollar appreciation in the first half of the 1980s, with very little variation in the exchange rate between the Singapore and US dollar.[10] As a result, the

[10] See Montiel (1997).

path of the nominal exchange rate essentially tracked that of the US dollar. However, during the regional crisis, the MAS was unable to maintain stability in the value of the Singapore dollar: Between the beginning of 1997 and January 1998, the Singapore dollar fell by 22 percent against US dollar, from S$1.4:US$1 to S$1.79:US$1. The currency continued to fluctuate after this, strengthening to 1.58 on May 1st.



Between 1975-87, the real terms of Singapore dollar experienced a depreciation, around 4 percent per year. However, during the following period, it experienced a major correction, appreciating at an average rate of 3 percent per year between 1988 and 1996, to approximately the original level in 1975.

2.2.7 Thailand

• Background

Thailand is well endowed with agriculture resources and abundant labour. It has an area of 514,000 square km and a population of 60.6 million (1997 year estimate). Over the last three decades until the recent regional financial crisis, the country had experienced impressively high rates of real GDP growth. Such high growth had been largely driven by exports of labour-intensive manufactures such as textiles, footwear and electronics and a significant inflow of foreign direct investment. In Thailand, there do exist mineral and gas abundantly, but no oil, so the country has a persistent current problem due to its heavy dependent on oil imports. Thailand is now trying to move up the production ladder from highly labour-intensive ones.

• Political history

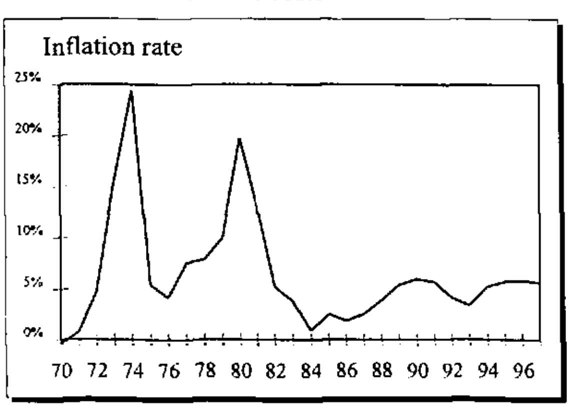
In 1932 the absolute monarchy was overthrown in favour of a constitutional monarchy which continues to the present time. Since then the monarchy has, however, little direct role in government. For the next four decades, the country was ruled by a succession of military governments and it was only in 1973 that the last of the military system was removed.

Civilian governments, weakened by rivalry, were usually short-lived and almost invariably ended in military take-overs. Throughout this turbulent period, the civilian bureaucracy lent an element of stability to the system. In the meantime, socio-economic pressures that have built up in the course of rapid economic growth have changed this general pattern, and subsequent military involvement in government has been limited to power-sharing with civilians, The last appointed prime minister with a military background was Prem Tinsulanond. He accepted the post in 1980 an ruled until 1988, stepping down in favour of a coalition led by a former major-general, Chtichai Choonhavan, the country's first elected prime minister in 12 years. In the late 1990s, the military rule ended.

• Economic structure

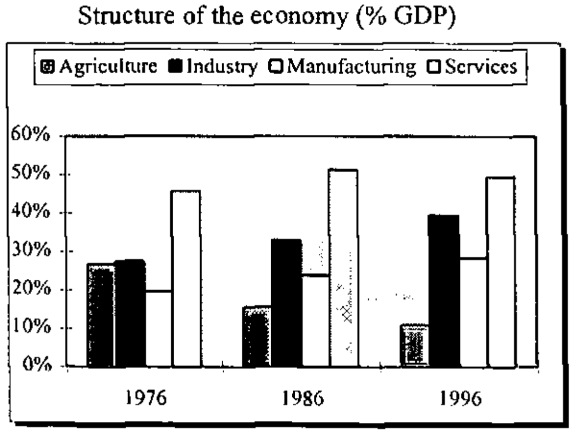
Based traditionally on agricultural exports, the Thai economy was transformed into one of the most diverse economies in South-east Asia in the 25 years to 1998. By the 1970s the active promotion of foreign investment had already created an industrial sector based on import substitute. In the 1980s an export-oriented manufacturing sector, based on labour-intensive items such as textiles and garments, began to develop. After 1990 the fastest growth was in higher-technology goods such as computer accessories and motor vehicle parts. Manufacturing, accounting for nearly 30 percent of GDP, is broadly-based and versatile. The sector was capital-intensive and heavily oriented towards import substitution until the 1984 baht depreciation, when it shifted to more labour-dependent industries such as integrated circuits and electronics assembly, footwear and toy making. In the 1980s, the manufacturing dominates the economy. Its share of GDP increased from 19.7 percent in 1976 to 23.9 percent in 1986, and reached to 28.4 percent in 1996. In the meantime, agriculture declined steadily from a share of 26 percent in GDP in 1976 to 15 percent in 1986, and further to 11 percent in 1996.

Inflation rate



Source: IMF

Structure of the economy (% GDP)



Source: World Bank

• Economic performance

Thailand had experienced impressively high rates of real GDP growth over most of the last 30 years. These periods were interspersed with short spells of slow growth as the country adjusted to new economic circumstances. Until the slowdown that began in 1996, Thailand generally fared better than its neighbours. The GDP averaged nearly 8 percent a year in the 1960s, 7.1 percent a year in 1970-79 and 7.4 percent a year in 1980-89, benefited from the import-substituting policy to a development strategy more closely based on thc free market. The import substituting sector grew out of programme of "state capitalism" undertaken during the 1950s. The government established the Board of Investment (BOI) in 1959 in an effort to stimulate both foreign and domestic investment, all behind a high level of protective barriers. During these decades, the inflation, as measured by CPI, was under the single digit level for most of the year, except four years between 1973-74 and 1980-81, when the economy was hit by oil price shocks.

During the 1970s, Thailand had weathered the first oil crisis of 1973 reasonably well, with average annual GDP growth of 8 percent in 1975-78, but the presence of underlying structural problems was indicated by widening current-account and budget deficits. By 1979, when the second oil shock hit, GDP declined to 4.8 percent. Then it followed the downturn of 1984-85 recession, most serious recession that the country had cxperienced since the late 1950s. After the government undertook a structure adjustment programme which was embodied into the Fifth-Five Year Plan - stabilisation, diversification, decentralisation and co-operation between the public and private sectors- the economy realised a remarkable average growth of 9.1 percent in 1987-95.

Since 1982, inflation has been reasonable low, averaging 2.4 percent, 4.7 percent and 4.8 percent per year over the five-year period from 1982-86, 1987-91 and 1992-96 respectively. It began to creep up from 1994, however, registering a 5.8 percent rise in 1996 in response to rapid credit expansion and periodic food shortages resulting from flooding. Prices moderated in 1997 as growth slowed and the rate of increase of CPI fell back to 5.6 percent. In 1998 inflation did pick up, but still remained well below the 10 percent threshold.

The East Asian financial crisis has plunged the Thai economy into a severe recession which has threatened to erode the gains of high growth rates over the past decade. GDP growth dropped in 1996 to 5.5 percent and the economy contracted by 0.4 percent in 1997 and massive 8 percent in 1998 - a far cry from the average growth rate of 8.8 percent achieved in 1990-96.

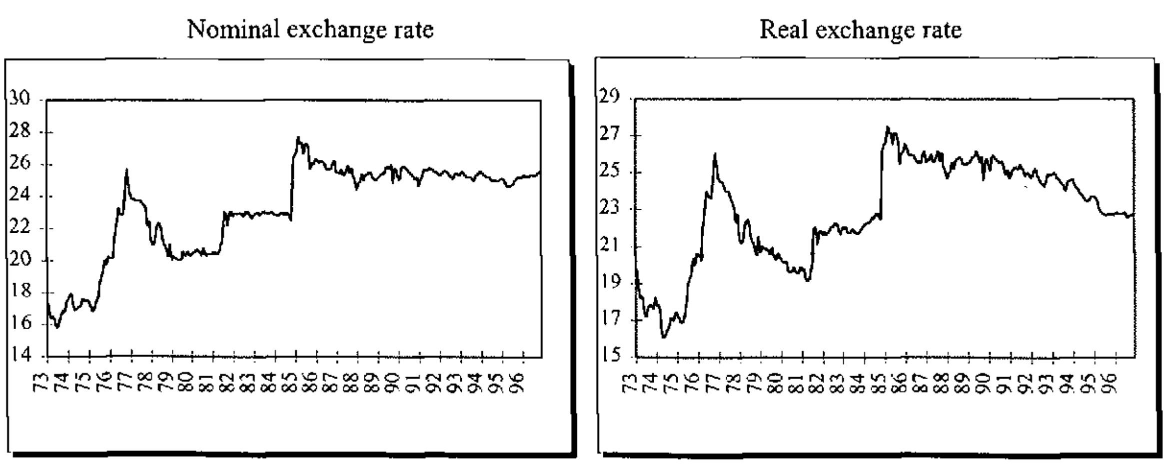
Main Economic Indicator (Thailand)

	1980-89	1990-96	1991	1992	1993	1994	1995	1996	1997
Real GDP growth (%)	**7.0**	**8.8**	**8.6**	**8.1**	**8.7**	**8.6**	**8.8**	**5.5**	**-0.4**
CPI Inflation (%)	**5.8**	**5.1**	**5.7**	**4.1**	**3.4**	**5.2**	**5.7**	**5.8**	**5.6**
Cur.balance/GDP (%)	**-3.2**	**-6.7**	**-7.5**	**-5.2**	**-4.9**	**-5.4**	**-7.9**	**-7.9**	**-2.0**
Exports / GDP (%)	**20.8**	**30.0**	**28.9**	**29.1**	**29.5**	**31.3**	**33.6**	**30.7**	**37.4**
Imports / GDP (%)	**27.0**	**38.6**	**38.3**	**36.5**	**36.8**	**37.7**	**42.1**	**39.9**	**39.9**
Gross saving / GDP (%)	**26.5**	**36.0**	**36.1**	**36.0**	**36.0**	**36.8**	**37.0**	**35.8**	**35.9**
Ex rate (av.; Bt/$)	**24.2**	**25.2**	**25.2**	**24.4**	**25.3**	**25.2**	**24.9**	**25.3**	**31.4**
Population growth (%)	**1.9**	**1.2**	**1.3**	**1.3**	**1.3**	**1.2**	**1.2**	**1.0**	**0.0**

Sources: Asian Development Bank, Key indicators of developing Asian and Pacific countries 1998, 1999.

• Exchange rate series

Until the baht went into free float in July 1997, the Thai currency was regarded as a strong and stable currency. While this was due in part to sound macroeconomic management, another factor was the peg to a basket of currencies denominated by the dollar, which limited fluctuations. Between 1963-78, a fixed exchange rate system tied the baht firmly to the US dollar, but dollar volatility led the Thai authorities to link the baht to a basket of currencies comprising the country's principal trading partners in March 1978. In November 1978, daily rate fixing was introduced with representatives from the Exchange Equalisation Fund (EFF) and commercial banks meeting at the Bank of Thailand to determine exchange rates against a basket of currencies, which included the US dollar, the yen, the Deutschmark, sterling, the Malaysian dollar, the Singapore dollar, and the Hong Kong dollar. The system collapsed in mid-1997, when economy was hit severely by regional crisis, and turned into a free float. In 1997, the currency devalued 24 percent. The fall of the baht eventually bottomed out at Bt56:$1 in mid-February 1998 - a fall of more than 50 percent from its pre-float level - before appreciating to Bt36.85:$1 by mid-1998.



2.3 Conclusion

In this chapter, we have briefly outline the features of economic development in seven East Asian economies from the last three decades to present. The most obvious characteristics exhibited so far were the rapid and sustained growth, and the dramatic structural changes accompanied with the fast growth. From what have been observed, the important element of economic development in East Asia seems to be a constant upgrading (high quality and more sophisticated products) of the industrial structure and exporting goods, the pattern similar to that of Japan experienced in the 1950s and 1960s. For example, in Japan, a particular manufacturing sector, such as the steel industry, experienced stages from an import surge to a domestic production surge replacing imports, to an export surge; and then the same pattern is repeated in the industry next in the sophistication ladder, such as the automobile industry. More recently, the same pattern of industrial development seems to have been repeated by Asian countries but with time lags. At a particular point of time, Japan is a leader followed by Singapore, which is followed by Korea, and then by Malaysia, Thailand, Indonesia and the Philippines.

The observation of the exchange rate movement reveals two important features of the series. First is the relative turbulence of all of the rates throughout the period. Second is the upward trend in the real exchange rate for all the countries shortly after the floating of the rates and then a downward trend approximately started around 1985.

All the above features show that all seven East Asian economies are exactly the types for which Balassa posited the relevance of the Balassa-Samuelson effect: economies characterised by rapid growth, presumably due to rapid manufacturing (and hence traded) sector productivity growth. As a result, these countries provide us with the good opportunity to study the behaviour of the exchange rate movements.

Chapter 3

Purchasing Power Parity: Theory and Evidence

• Introduction

This chapter focuses on the purchasing power parity (PPP) hypothesis and the related topics. Specifically, the theory of PPP and the current research on this topic will be extensively reviewed.[1] The genesis of this perception was linked to the development of the quantity theory of money,[2] and the theory posits that the behaviour of exchange rates is related to the national price levels between two countries. Although attractive from the theoretical perspective, however, the empirical evidence on the theory provides mixed results. In what follows, the PPP doctrine will be introduced first in section 3.1, and its implication of mean reversion behaviour of real exchange rates is illustrated in section 3.2. Then in section 3.3 the emphasis is turned to empirical evidence with specifically focus on the recent studies. The problems arising from testing PPP are discussed in section 3.4, which is followed by the three modifications of PPP in section 3.5. Finally, the conclusion is provided in section 3.6.

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[1] In modern models of exchange rate dynamics, PPP is a key element since it is supposed as a long-run equilibrium condition. For example, the two standard theories of exchange rates - the Dornbusch overshooting model and the portfolio-balance model - as well as many other models contain PPP as the long-run equilibrium rate toward which people expect the actual exchange rate to gravitate after an initial shock.

[2] On the genesis of PPP see Myhran (1976), Frenkel (1978), and Officer (1982).

3.1 Absolute and relative PPP

The PPP hypothesis has its roots in the nineteenth century and owes its modern development to the writings of Cassel (1922) which states that exchange rates should tend to equalise relative price levels in different countries. So the starting point of PPP is the law of one price, that is, in an integrated competitive market, the law of one price would prevail and as such, the price of a given good would be the same when quoted in the same currency, that is,

$$P_t^i = S_t \, P_t^{i^*} \tag{3.1}$$

where P_t^i is the price of good i, the asterisk denotes the foreign country and S_t is the exchange rate defined as the amount of home currency required to buy one unit of foreign currency. Thus, the price of good i in the home currency must equal its price in the foreign country multiplied by the foreign exchange rate.

The law of one price is based upon the idea of perfect good arbitrage. If the price ratio between the two countries differs from the nominal exchange rate then arbitrage opportunities exist, the resulting trade in goods equates the price ratio with the nominal exchange rate.

The PPP theory comes in two forms. One is based on a strict interpretation of the law of one price and it is termed as absolute PPP, that is, if one takes a bundle of goods in one country and compares the price of that bundle with an identical bundle of goods sold in a foreign country converted by the exchange rate into a common currency of measurement, then the price between two countries will be equal. Consequently, by summing all prices, the absolute PPP is obtained,

$$S_t = P_t \,/\, P_t^* \tag{3.2}$$

where $P_t = \sum_{i=1}^{n} w^i p_t^i$, the price of a bundle of goods expressed in the domestic currency, $P_t^* = \sum_{i=1}^{n} w^i p_t^{i*}$, the price of an identical bundle of goods in the foreign country expressed in terms of the foreign currency, w^i denotes a weight. Note that the absolute version of PPP is based on the presumption that the prices in indices are constructed in the same manner and are comprised of the same goods in different countries. According to (3.2), an increase in the domestic price level should results in corresponding depreciation of the domestic currency against foreign currency.

However, in reality, the existence of transportation costs, imperfect information, tariff and other impediments to trade will prevent condition (3.1) or (3.2) to hold exactly. None the less, it is argued that relative PPP can be expected to hold even in the presence of such distortions. The relative PPP is expressed as:

$$\%\Delta S = \%\Delta P - \%\Delta P^* \tag{3.3}$$

where %ΔS is the percentage change in the exchange rate, %ΔP is the domestic inflation rate, and %ΔP is the foreign inflation rate. The exchange rate, accordingly, depreciates (appreciates) if the inflation rate in the home country is greater (smaller) than the inflation rate in the foreign country.

Since PPP states that equilibrium value of the nominal exchange rate between the currencies of two countries will equal the ratio of the country's price level, thus, a deviation of the nominal exchange rate from PPP has been viewed as a measure of a currency's over/under valuation.

As a practical matter, empirical tests of PPP usually test for relative PPP, and frequently use the price indices instead of price levels. An expression for relative PPP using price indices can be obtained from equation (3.2) by dividing the nominal exchange rate and price levels by base period values. This yields:

$$S_t / S_0 = [P_t / P_0] / [P_t^* / P_0^*] = PI_t / PI_t^* \qquad (3.4)$$

where PI and PI* are the price indices for the domestic and foreign countries, respectively. These indices have identical weights and a common base period 0. Taking the logarithm of equation (3.4), the following is obtained,

$$s_t = s_0 + p_t - p_t^* \qquad (3.5)$$

where s_t and s_0 are the logarithms of the nominal exchange rates at time period t and zero, respectively, and p_t and p_t^* are the logarithms of the domestic and foreign price indices. Defining η_t as a mean zero stochastic error term capturing the temporary deviations from PPP, relative PPP can be expressed as

$$s_t = s_0 + p_t - p_t^* + \eta_t \qquad (3.6)$$

Relative PPP as given in equation (3.6) states that the accumulated percentage change in the nominal exchange rate from base period zero to period t is equal to the accumulated inflation differential associated with the two countries plus a random walk error.

The PPP theory has two important implicit restrictions. The first restriction is symmetry between the two price indices. The second one is the proportionality between the nominal exchange rate and the relative price defined from the symmetry restriction. For the PPP hypothesis to be valid, the necessary condition is that the three variables comprised by the PPP relationship should have a long-run, stable equilibrium relationship and the coefficient restrictions should be accepted. It is possible that the necessary condition exists but the coefficient restrictions are rejected. In this case, PPP is rejected.

According to the PPP doctrine, it identifies price level changes in two countries as the major determining factor of movements in the exchange rate between the currencies of the two countries. Although PPP has been sometimes referred to as "theory" of exchange rate behaviour, however, it is important to note that PPP relationship is an equilibrium and not a causal relation from saying the price level to the exchange rate, or vice versa.[3] In other words, inflation differentials do not cause exchange rate changes. A more appropriate interpretation of PPP views it as a long-run equilibrium relationship between endogenous variables, that is the prices and the exchange rate are endogenous since they are determined simultaneously by other factors. The other factors are called exogenous variables which may change independently. Given a change in an exogenous variable, both the prices and the exchange rate will change. Deviations from PPP will occur if domestic and foreign prices and exchange rate changes at different speeds. Thus the theory is better characterised as a description of the behaviour of the exchange rate and prices in the two countries. PPP implies that relative price levels will always equal the current exchange rate.

3.2 Mean reversion behaviour of real exchange rates

PPP also has specific implications for the time-series behaviour of real exchange rate, that is, real exchange rates never change, at least not permanently. A real exchange rate is defined as the nominal exchange rate multiplied by the ratio of the foreign to the domestic price levels, that is,

[3] See Isard (1995, p.59) and Grauwe (1996, p.92) on exchange rates and national price levels.

$$Q_t = S\frac{P_t^*}{P_t} \tag{3.7a}$$

The logarithm of the real exchange rate, q_t, can be defined as,

$$q_t = s_t - (p_t - p_t^*) \tag{3.7b}$$

It is evident from the equation (3.7b) that the real exchange rate is unity if absolute PPP holds at each point in time, and constant if relative PPP holds. Since PPP can be taken as an equilibrium relationship between exchange rate and relative price levels, and deviations from equilibrium are possible, so q_t may deviate from its equilibrium level in the short-term, due possibly to the differential adjustment rates of price indices and asset prices. But in the long-run, q_t must return to its equilibrium level for PPP to hold, or in other words, the necessary condition for PPP to hold in the long-run is that q_t must have a constant mean and the tendency to revert to that mean, i.e., the real exchange rate series must be mean-reverting process over time, not driven by permanent shocks. Conversely, if the real exchange rate follows a random walk process,[4] this implies that it moves randomly without any predictable pattern. If this is a case, then the real exchange rate does not tend to revert to some mean level and therefore cannot be viewed as constant in the long-run. Under this conditions, the notion of PPP is rejected because the movements in the real exchange rate appear to be more than temporary deviations from some equilibrium value.

Real exchange rates are important not only for quantifying deviations from PPP but also for analysing macroeconomics demand and supply conditions in open economy. Since the 1980s, the real exchange rate has been at the centre of economic policy discussions for at least

[4] Although random walks and non-stationary processes are different concepts, for the detail see Campbell, *et al* (1997), many papers on testing real exchange rates use these two terms interchangeably. Here we also follow the same rule, using the random walk to refer to a non-stationary process in general.

two reasons. First, this relative price has been more variable in the floating exchange rate period than in the preceding era of fixed exchange rates, see Frankel and Meese (1987) and Dornbusch (1980) for survey of this literature. Second, the real exchange rate measures a country's competitiveness in international trade. An appreciation of the real exchange rate, a decrease in q_t (due either to an appreciation of the nominal exchange rate, a decrease in s_t or an increase in p_t or fall in p_t*) is associated with a decline in competitiveness and vice versa. It is clear that this price is related to international trade patterns because the competitive position of an individual exporting (importing-competing) firm in a country affected adversely by an appreciating (depreciating) real exchange rate. If changes in the nominal exchange rate over time offset any differential inflation, then clearly a country's competitiveness and its real exchange rate remain constant.

In the tests of mean reversion of real exchange rates, the PPP theory has been the dominant theory of the long-run equilibrium real exchange rate (ERER) to which the series is assumed to revert. However, the empirical studies reveal clearly that PPP is an inadequate theory of the ERER. Countries with high per capital income, with higher capital/labour ratios and with greater differentials in labour productivity between tradable and non-tradable sectors, tend to have higher prices. These empirical results are consistent with Balassa-Samuelson hypothesis that with rapid productivity growth in the tradables than the non-tradables sector, real exchange rates that are based on price indices which include non-tradables will tend to increase with per GDP. In other words, the ERER must be treated as a function of a vector of real variables, of which, the ratio of domestic to foreign prices is just one. Despite much research, however, there is no consensus on which variables cause changes in the real exchange rate. Like any asset price, real exchange rates are related to the determinants of the relative supply and demand curves now and in the future. With real exchange rates, the relevant determinants are those affecting the relative supplies and demands for the currencies of two countries. Claims have been made, however, that real exchange rates often differ substantially from levels consistent with the underlying economic fundamentals and that these differences persist for long periods.

3.3 Current research on simple PPP

Reviewing the previous studies, there is a huge body of literature on the study of the validity of PPP. These studies feature different sample periods, different currencies, different specifications, and different estimation methods. Table 3.1 lists some of the empirical tests with their salient features.

Glancing at Table 3.1, it is obviously that, while the currencies investigated differ, the majority of studies focus on bilateral rates of the industrialised countries against the US dollar. Sometimes these studies include tests of bilateral rates of one currency other than the US dollar against another by computing the cross rates from the data set, whereas others explicitly select a bilateral rate against a currency, such as German mark, for the base. Sample periods commonly investigated are the era of flexible exchange rates that began in the 1970s, though there are studies where the sample period covered two centuries. The price indices used are also different. The examples of indices available for research are the consumer price index

Table 4.1 Selected studies of PPP

Authors	Data series considered	Data frequency (Price index)	Data period	Methodology	Model sepcification	Results
Abuaf and Jorion (1990)	US against 10 industrial countries	Annual Monthly (CPI)	1973-87 (Monthly) 1900-72 (Annual)	unit roots test	$q_t = s_t - (p_t - p_t^*)$	Reject the random walk
Baharumshah and Ariff (1997)	Malaysia, Indonesia, Thailand, the Philippines, and Singapore against US	Quarterly (CPI)	1974:1 - 1993:4	Engle-Granger	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	No cointegration
Bahmani-Oskooee (1998)	11 Middle Eastern countries	Quarterly (CPI)	1971:1 - 1994:4	ADF KPSS	effective real exchange rates	KPSS support the stationary of the real effective rate, thus PPP, while ADF test does not
Baillie and Selover (1987)	US, Japan, West Germany and Canada	Monthly	1973:3 - 1983:8	Engle-Granger	$s_t = \alpha_0 + \beta (p_t - p_t^*) + v_t$	No evidence of cointegration
Chen (1995)	EMS countries bilateral exchange rate between Belgium, France, Germany, Italy and the Netherlands	Monthly	1973:4 - 1990:12	Johansen-Juselius KPSS test	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$ $q_t = s_t - (p_t - p_t^*)$	Evidence of cointegration and real exchange rate is stationary Support PPP
Cheung and Lai (1998)	France, Germany, Japan, UK and US	Monthly (CPI)	1973:1 - 1994:12	DF-WS test DF-GLS test	$q_t = s_t - (p_t - p_t^*)$	Supportive evidence of PPP reversion
Cheung and Lai (1993)	US against UK, France, Germany, Switzerland and Canada	Monthly (CPI, WPI)	1974:1 - 89:12	Johansen-Juselius	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	Support cointegration for all currencies, do not report symmetry and propertinarity hypothesis

Chowdhury and Sdogati (1993)	France, Germany and Italy against US and Germany	Monthly (CPI)	1972:1 - 1990:12	Engle-Granger ADF	$s_t = \alpha_0 + \beta(p_t - p_t^*) + v_t$ $q_t = s_t - (p_t - p_t^*)$	PPP is rejected before EMS, after 1979, is still rejected except for France and Italy with Germany as the base country.
Cochran and Define (1995)	US dollar against Austrian Schilling, Canadian Dollar, Danish Krone, French Franc, German Mark, Italy Lira, Japanese Yen, Norwegian Krone, Swedish Krone, Swiss Franc, and British Pound	Monthly (CPI)	1975:1 - 1991:12	Johansen-Juselius	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	support cointegration for all currencies except Danish Kroner, PPP vector is reject for each currency
Corbae and Ouliaris (1988)	US dollar between Candian dollar, French france, Dectsche mark, Italian lira, UK pound and Japanes yen	Monthly (CPI)	1973:6- 1986:9	Engle-Granger	$s_t = \alpha_0 + \beta(p_t - p_t^*) + v_t$	reject PPP
Diebold et at (1991)	Bilateral between Belgium, France, Germany, Sweden, the UK and US	Annual (CPI, WPI)	Around 1830-1913	Fractional integration	$q_t = s_t - (p_t - p_t^*)$	PPP holds in the long-run
Enders (1988)	US dollar against Germany, Canada and Japan	Monthly (WPI)	1960:1 - 1971:4 1973:1 - 1986:11	Engle-Granger	$s_t = \alpha_0 + \beta(p_t - p_t^*) + v_t$	mixed results
Edison and Fisher (1991)	Pairs Between Belgian franc, Franch franc, German mark, Italyian lira, Dutch guilder, Poung sterling	Monthly (CPI)	1973:4 - 1979:2	Engle Granger	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	No evidence of cointegration
Edison et al (1997)	Australia, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, Turkey, the UK and the US, with US and Germany as the base ciountries	Quarterly (CPI)	1974:1 - 1992:4	Johansen-Juselius Horvath-Watson	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	moderate PPP

Fisher and Park (1991)	Bilateral exchange rates between Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the UK and the US	Monthly (CPI, WPI)	1973:3 - 1988:5	Park (1990) approach null of cointegration	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	evidence of cointegration restrictions are rejected
Flynn and Boucher (1993)	Canada dolllar, Japanses yen against US dollar	Monthly (CPI)	1963:1 - 70:5 (C) 1957:1 - 72:12 (J) 1974:1- 87:12 (All)	Dickey-Fuller test Perron test Engle-Granger	$q_t = s_t - (p_t - p_t^*)$ $s_t = \alpha_0 + \beta(p_t - p_t^*) + v_t$	No evidence of PPP
Glen (1992)	US against 9 Industrial countries	Annual (CPI, WPI)	1900-87	Variance ratio tests	$q_t = s_t - (p_t - p_t^*)$	Reject the random walk except Canada
Henricsson and Lundback (1995)	Bilateral exchange rate between USA, Japan, Germany and the UK	Monthly (CPI)	1960:1-1989:12	DF test KPSS test	$q_t = s_t - (p_t - p_t^*)$	reject ppp
In and Sugema (1995)	Austrialia between Canada, France, Germany, Itlay, Japan, Korea, the Netherlands, Singapore, Switzerland, the UK and the US	Quaterly (CPI, WPI)	1972:1 - 1986:2	Johansen-Juselius	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	Support cointegration in all cases for both CPI and WPI based analysis, coefficient restriction is rejected
Kahn and Parikh (1998)	South African rant between US dollar and British pound	Monthly (CPI, PPI)	1975.:1 - 1994:12	Dickey-Fuller test Cointegration test	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	
Kim (1990)	US dollar against Canada, Frace, Itlay, Japan, UK	Annual (CPI, WPI)	1900-1987 (WPI) 1914 - 1987 (CPI)	Engle Granger	$s_t = \alpha_0 + \beta(p_t - p_t^*) + v_t$	PPP is found with WPI except Canada, PPP is found with CPI except Canada, yen and pound
Koedijk et al (1998)	A panel with 17 industrialised countries	Quarterly (CPI)	1973:1 - 1996:3	Panel unit root	$q_t = s_t - (p_t - p_t^*)$	PPP is strongest for the German mark and weaker for US dollar

Kugler and Lenz (1993)	DM vis à vis 15 currencies: the Swiss Franc, French Franc, Lira, Pound Sterling, US Dollar, Yen, Austrian Schilling, Dutch Guilder, Belgian Franc, Spanish Peseta, Swedish Krone, Danish Krone, Canadian Dollar, Portuguese Escudo and Norwegian Krone	Monthly (CPI)	1973:1-1990:11	Johansen-Juselius	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	10 currencies are cointegrated with 6 supporting the strong form of PPP, for remaining 5 currencies the results are mixed
Layton and Stark (1990)	UK, West Germany, Canada, France, Italy and Japan	Monthly	1963 - 1987			no evidence of cointegration
Lin and He (1991)	Canada, France, West Germany, Japan, UK India, Korea, Maylasia, Philippines and Thailand all relative to US	Monthly (CPI)	1974:1-1989:1 1978:1-1988:6	Variacne ratio test	$q_t = s_t - (p_t - p_t^*)$	Reject random walk real exchange rate
Lothian (1990)	Japan, US UK, France	Annual	100 years	unit root		mean reversion found
Lothian and Taylor (1996)	US dollar - pound sterling French franc - pound sterling	Annual (WPI)	1791-1990 1803-1990	DF tests	$q_t = s_t - (p_t - p_t^*)$	Reject the random walk
MacDonald (1993)	US dollar bilaternal between Canadian dollar, French franc, Germany mark, Japanese yen and UK pound	Monthly (CPI, WPI)	1974:1-1990:6	Johansen-Juselius	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	support weak form PPP
Mark (1990)	US dollar against Begium, Canada, France, Germany, Italy, Japan, and UK	Monthly (CPI)	1973:6-1988:2	Engle-Granger	$s_t = \alpha_0 + \beta (p_t - p_t^*) + v_t$	no evidence of cointegration
Mahdavi and Zhou (1994)	Bilateral US dollar with 13 high inflation countries	Quarterly (WPI)	1976-1986	Johansen-Juselius	$s_t = \alpha_0 + \beta (p_t - p_t^*) + v_t$	Evidence of PPP in favour absolute or relative versions for 8 countries

McNown and Wallace (1989)	Argentina, Brazil, Chile and Israel	Monthly (CPI, WPI)	1972:1 - 1986:12	Engle-Granger	$s_t = \alpha_0 + \beta (p_t - p_t^*) + v_t$	Support of PPP
Nita Thacker (1995)	Poland, Hungary vis-a-via US, UK, Germany	Monthly (CPI, WPI)	1981:1 - 1993:2	Engle-Granger	$s_t = \alpha_0 + \beta (p_t - p_t^*) + v_t$	No evidence of cointegration
Patel (1990)	Pairs between the US, UK, Canada, West Germany, The Netherland and Japan	Quarterly (WPI)	1974:1 - 1986:1	Engle-Granger	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	3 out of 15 cases are cointegrated, coefficients restrictions are rejected
Perron and Vogelsang (1992)	US dollar against pound sterling and Finnish markka	Annual (CPI, GNP defaltor)			$q_t = s_t - (p_t - p_t^*)$ $q_t = \alpha_0 + \beta_1 q_{t-1} + \varepsilon_t$	Reject random walk
Phylaktis and Kassimatis (1994)	Indonesia, Korea, Malaysia, the Philippines, Thialand, Taiwan, Singapore and Japan relative to US	Monthly (CPI, WPI)	1974:1-1987:8	GLS method	$q_t = \alpha_0 + \beta_1 q_{t-1} + \varepsilon_t$	Reject random walk real exchange rate excluding Japan
Pipperger (1993)	Swiss franc against Austria, West Germany, France, Demank, UK, US, Norway, Belgium, Canada, Japan and the Netherlands	Monthly (WPI)	1973:1 - 88:6	Engle-Granger	$s_t = \alpha_0 + \beta_1 p_t + \beta_2 p_t^* + u_t$	7 of 11 countries accept the cointegration, restrictions are rejected
Richard and Lundback (1995)	Bilateral, USA, Japan, Germany, UK	Monthly (CPI)	1960 - 1990	DF tests	$q_t = s_t - (p_t - p_t^*)$ $q_t = \alpha_0 + \beta_1 q_{t-1} + \varepsilon_t$	Reject PPP
Taylor (1988)	US dollar against UK, West Germany, France, Canada and Japan	Monthly (WPI)	1973:6 - 1985:12	Engle-Granger	$s_t = \alpha_0 + \beta (p_t - p_t^*) + v_t$	noevidence of cointegration

(CPI), the wholesale or producers price index (WPI or PPI) and the gross national product deflator (GNP).[5]

The specifications used to testing for PPP differ, according to whether the trivariate relationship between the exchange rate, the domestic price series, and the foreign price series, which imposes neither symmetry nor proportionality as follow,

$$s_t = \alpha_0 + \alpha_1 p_t + \alpha_2 p_t^* + u_t$$

or the bivariate relationship between the exchange rate and the domestic-foreign price ratio, which implicitly imposes symmetry as follow,

$$s_t = \beta_0 + \beta_1 (p_t - p_t^*) + v_t$$

or the univariate real exchange rate, which imposes both symmetry and proportionality as follow,

$$q_t = s_t - p_t - p_t^*$$

As far as the methodology is concerned, since the mid 1980s, various advances in time series analysis have been used to test for PPP hypothesis, which include the Dickey-Fuller (DF) or Augment Dickey-Fuller (ADF) tests and the variance ratio tests to explore the non-stationary behaviour of real exchange rates; and cointegration techniques provided by Engle-Granger (1987) two-step approach and Johansen and Juselius (1990)'s maximum likelihood estimation procedure to investigate the comovement between nominal exchange rate, domestic

[5] The consumer price index and GNP deflator are broadly based on price indices that measure the overall purchasing power of money, while wholesale price index is more heavily weighted toward tradable goods. See Officer (1976) for a discussion o the issues.

and foreign price levels. In addition, there is also a growing literature in using panel data for the recent floating rate period.[6]

Results reported differ, with broadly mixed conclusions. In the following, we present the survey of simple PPP- Cassel's (1922) notion that exchange rates should tend to equalise relative price levels in different countries. The organisation traces out the evolution of the literature, from static test of PPP- based on the linear regression of exchange rate on relative prices, to the modern unit root test - tests of whether the real exchange rate is stationary, and the cointegration approach - tests of the comovement between nominal exchange rate and relative prices, and to the panel data test - tests of convergence to PPP based on cross - country data sets. After reviewing the previous research, we can get a clear graph on how PPP works.

Regression tests of PPP

In the mid 1970s, the conventional tests of PPP involved the use of regression analysis, that is, to test the coefficient restrictions imposed by PPP. Frenkel (1978) runs regression of the following form,

$$s_t = \alpha_0 + \beta (p_t - p_t^*) + v_t$$

where v_t is the disturbance term, for the dollar-pound, franc-dollar and franc-pound exchange rate for monthly data over the period February 1921-May 1925 during which the exchange rates were flexible. His results can be summarised as supportive of the PPP hypothesis in both the absolute and relative versions. However, Frenkel (1981) uses data from recent floating exchange rate experience for the dollar-pound, dollar-franc and dollar-deutschmark exchange

[6] The methodology used in testing for PPP and the rationale behind these tests will be described in detail in Chapter 5.

rate and finds that PPP is not supported by the data. Similar results arc reported by Krugman (1978) for both the inter - war and the recent floating experience.

Thc main problem with above test is the failure to take explicitly into account the possible non-stationarity of relative prices and exchange rates. Since it has been noted that exchange rates and prices are non-stationary, the standard hypothesis test of proportion β=I is invalid.

Random walk hypothesis of real exchange rates

In the early 1980s, with the development of econometric techniques, a further test of PPP shifts attention to examine the time series properties of real exchange rates. Studies at this stage take into account the nonstationarity of variables. A means of testing for PPP in a framework that allows for non-stationarity is to define the real exchange rate and to test if this series follows a random walk, or is non-stationary.[7] If the null hypothesis cannot be rejected, then the real exchange rate contains a unit root and does not revert to its mean value, meaning, consequently, that PPP does not hold in the long-run. In determining whether a variable follows a non-stationary process, the unit root (or variance ratio) test is the common technique in econometrics. With this method, many previous studies have reported that the random walk hypothesis cannot be rejected for the real exchange rate series in the floating period, for example, Adler and Lehman (1983), Darby (1983), Hakkio (1984), Meese and Rogoff (1988), and Baillie and McMahon (1989), and hence, reject the notion of long-run PPP. Thus, such results imply that shocks have a permanent effect on the level of the real exchange rate, while

[7] Although random walk and non-stationary process are used interchangeably and the latter is more strict, the random walk hypothesis is widely adopted as a common term in this regard.

changes are unpredictable, and that there is little or no tendency for nominal exchange rate and prices to adjust in such a way as to promote PPP.

While most of the empirical evidences do not reject the unit root hypothesis for the real exchange rate for most countries in the post - Bretton Woods era and, hence, reject the notion of long-run PPP, the issue remains controversial. The reason is that some researchers have found evidence to reject the random walk hypothesis in some cases. For example, using monthly data between September 1975 and May 1981, Cumby and Obstfeld (1984) reject the random walk hypothesis for the real exchange rate between United State and Canada. Abuaf and Jordan (1990) test the real currencies of 10 industrialised countries by applying DF and ADF tests in a seemingly uncorrelated regression framework. Their data span two period: 1973-87 and 1900-72. They report the results that random walk is rejected for the data spanning 1900-1972. For the data spanning 1973-87, a random walk is rejected when the critical values are adjusted for a non-zero constant. Based on these, they report that the real exchange rate is mean reverting.

On the other hand, Lin and He (1991) adopt the variance ratio and Box-Pierce Q test to test the random walk hypothesis for the real exchange rates, using two groups of the monthly data, one from five Asian countries and other from five industrialised countries over the period from January 1974 to January 1989. The variance ratio test rejects the random walk hypothesis for both groups and offers evidence that mean reversion is quick in the Asian countries relative to industrialised countries. However, the Box-pierce Q statistics contradicts these results and cannot reject the random walk hypothesis. Overall, their results are mixed but offer interesting insight into the speed of mean reversion in Asian and industrialised economies.

However, doubts were raised at this stage of the debate over the power of standard tests to discriminate between a true random walk and a near random walk, see Cochrane (1988) and Campell and Perron (1991). Given the phenomenal volatility of floating exchange rates, it can be very hard to distinguish between slow mean reversion and a random walk of the real exchange rate, especially for the post Bretton-Woods data since the current floating rate period is too brief to assess accurately the validity of PPP. Froot and Rogoff (1994) calculated that, if PPP deviations damp sufficiently slow, suppose that the half-life of PPP deviations is 3 years, then it may require 76 years for one to be able to reject reliably the existence of unit root in real exchange rates. With a longer half-life, even more data would be required. Put differently, the PPP deviations can be slow to reverse, and conventional econometric techniques have low power to identify stationary but persistent dynamics. Thus, it is argued the fact that previous studies fail to reject a random walk in the real exchange rate series is probably due to the poor power of the tests employed rather than the evidence against long-run PPP.

One of the approaches to address the low-power problem is to expand the sample period. Frankel (1986), using 116 years (1869-1984) of data for dollar/pound real exchange rate, is able to reject the random walk hypothesis for the real US dollar / British pound using annual data between 1869 and 1984, but is unable to reject the hypothesis using data from 1945 to 1984. He finds that a simple first-order autoregression yields a coefficient of 0.86, which implies that PPP deviations have an annual decay rate of 14 percent and a half life of 4.6 years. His rejection of unit root null is significant at the 5% level, using Dickey-Fuller confidence intervals.

The long-horizon data sets are also employed by several authors during the 1990s, with a variety of different approaches, and almost invariably tend to find evidence of mean reversion in the real exchange rate. Diebold, Husted and Rush (1991), for example, look at the data during the Gold Standard era, with shortest data spans 74 years and longest 123 years, and are able to reject the random walk model by adopting the fraction integration. They find that PPP holds in the long-run for each of the currency and the typical half-life of a shock to parity is approximately 3 years. Similarly, the random walk model is rejected by Grilli and Kaminsky (1991), with data spanning 1885-1986 and covering various exchange rate regimes: the gold standard, fixed rates, flexible rates, and the inter-war period, using both Phillips-Perron tests and variance ratio tests. Glen (1992), who employs the variance ratio tests with annual data spanning 1900-87, finds similar results for nine exchange rates of industries countries against the US dollar. Lothian and Taylor (1996) present some unit root test for the real exchange rate of the US dollar - pound sterling (1791-1990) and French franc-pound sterling (1803-1990) based on annual observations. The data cover nearly two centuries. They find strong evidence of mean reversion in both rates with an estimated half-life being 4.7 years for the dollar-pound and 2.5 years for the franc-pound rates.

Thus, Lothian (1998), based on studies using long historical data sets, concludes that real exchange rates contain economically important mean-reverting components and that, as a result, PPP is still a useful first approximation. Moreover, Lothian shows that the difficulty of finding evidence of PPP with the United States dollar as the numerator currency is primarily the result of 1979-1982 period during which the dollar first strongly depreciated and afterwards strongly appreciated.

The above studies based on the analysis of long-run spans of data do find the mean reversion of real exchange rate, however, it ignores the changes in exchange rate regime. From the statistical point of view this raises the questions, since the data generating process is likely to be sensitive to the exchange rate regime. Thus, it is not clear whether the findings based on long-sample data confirm simply the presence of parity reversion in the pre-modern float period or show its presence over the modern float as well. In addition, it is also argued that test of unit roots in real exchange rate precludes the coefficients, that is, the construction of the real exchange rate implicitly restricts the coefficients corresponding to the domestic and foreign price levels as -1 and 1. Since the measurement error as well as the trade barriers, the exchange rate may not move one by one with price levels as implied by PPP. In this regard, the recently developed cointegration methodology offers a more appropriate econometric test for this kind of relationship, and there has been a rapid accumulation of published materials on this topic. We can see this in the following.

Comovement between nominal exchange rate and relative price levels

If two or more variables, such as exchange rate and the corresponding price levels, are cointegrated then it means that in the long-run they will settle down together in a unique way, without wandering away far apart. For the implication of the present study, long-run PPP is generally interpreted as the comovement of the nominal exchange rate and the relative price levels between two countries over time.

The early application of cointegration technique to testing for PPP is based on the Engle and Granger (1987) two-step approach, or single-equation technique. For the recent experience with flexible exchange rates, examples can be seen in Taylor (1988), Enders (1988), Mark (1990) and Patel (1990), among others. Mark (1990) investigates a number of OECD bilateral rates - Belgium, Canada, France, Germany, Italy, Japan, and the UK against the US dollar, using monthly observations from June 1973 to February 1988. Three sets of bilateral relations are examined with the US, the UK and Germany each serving as the home currency, based on the Engle-Granger two-step procedure and testing for the bivariate specification of PPP. He finds only one instance (out of 15) when the null hypothesis of no cointegration is rejected. Mark summarises the results by suggesting that the evidence for long-run PPP is weak and that changes in the nominal exchange rate and relative prices are permanent.

In contrast to above studies on the post - Bretton Woods era, Kim (1990) uses the data sets spanning most of the century. He examines the long-run bilateral exchange rate - price relationship between the Unite State and five countries - Canada, France, Italy, Japan, and the UK, based on the Engle-Granger method for the bivariate specification. He finds that the nominal exchange rate is cointegrated with both WPI and CPI indices (except for the Canadian dollar with both CPI and WPI , and the yen and pound with CPI index), and the coefficient between the exchange rate and the price indices is close to one.[8] In general, he concludes that

[8] Such positive results may also be the reason of using long span of data.

the hypothesis of non-cointegration is more strongly rejected when the WPI is used than the CPI index is used. He explains the difference as subsequent changes in the price of non-traded goods relative to traded goods.

In general, the above empirical tests using Engle-Granger two-step procedure can be summarised by saying that there is no long-run tendency for nominal exchange rates and relative prices to settle down on an equilibrium track, or in other words, there is no bound between these variables. That one disadvantage should be noted in these studies is that almost all of the authors preclude an actual test of the proportionality and symmetry of the coefficients with respect to the exchange rate, although the estimated values are often far from 1 and -1.

The above cointegration tests based on Engle-Granger procedure have been criticised by a number of researchers, for example, MacDonald (1993), Cheung and Lai (1993), Cochran and DeFina (1995), who have argued that the failure to find a cointegration relationship between relative prices and exchange rate may be due to the econometric method used, rather than the absence of a long-run relationship. These authors all advocate using the recently developed multivariate cointegration methodology of Johansen (1988) and Johansen and Juselius (1990) which is based on the systems estimation techniques to test for the number of cointegrating vectors among relative prices and exchange rates. This maximum likelihood approach allows testing for PPP in a trivariate framework and avoids some drawbacks of the Engle-Granger two-step regression approach.[9]

[9] See Chapter 5 for the comparison of these two approaches.

Using Johansen procedure, MacDonald (1993) tests for a long-run relationship between exchange rates and relative prices for five bilateral US dollar rates of the Canadian dollar, French franc, Germany mark, Japanese yen and UK pound, and also tests for the proportionality of the exchange rate with respect to relative prices, using post - Bretton Woods data from January 1974 to June 1990. He classifies the distinction between what he calls the weak-form PPP and strong-from PPP. The weak-form PPP requires deviations from a linear combination of exchange rates and national price levels be stationary; while strong-form PPP needs not only the stationarity of residuals, but also the degree one homogeneity of the exchange rate with respect to relative prices. In contrast to many other researches, he reports that weak-form PPP receives very strong support from the data, whilst strong-form PPP receives practically no support. In other words, there is a long-run relationship between a number of bilateral US dollar exchange rates and their corresponding relative prices; the proportionality of the exchange rate to relative prices does not give much support from the data.

Similar research is also followed by Cheung and Lai (1993), Cochran and DeFina (1995), Kugler and Lenz (1993), Pippenger (1993), and among others. The common features of this group of studies are that: (1) all the data are based on the recent floating exchange rate period for the industrialised currencies; (2) they all use the Johansen procedure; and (3) they all report the results that without imposing the symmetry and proportionality, cointegrating vectors are present for most of the currencies. However, with restricting models, that is by imposing the vector implied by theoretical PPP, the null hypothesis that the PPP vector is contained in the cointegration space can be rejected for nearly every currency. Overall, their evidence is less in favour of strict PPP hypothesis, and they argue that given the transportation cost, tariffs, and cross-country differences in the construction of price indices, PPP may be consistent with a cointegrating vector rather than the theoretical one. They suggest that any findings of cointegration leads relatively strong support to the proposition that PPP holds as a long-run equilibrium condition.

While all of the above experiments take the null hypothesis as no-cointegration, Fisher and Park (1991) test the PPP based on the null hypothesis of cointegration, using Park's (1990) approach. They examine the monthly bilateral exchange rates of the eleven major industrialised countries,[10] which comprises 55 bilateral exchange rate for the period between March 1973 and May 1988, using both consumer price and wholesale price indices. The authors report that there is almost no evidence that the United States' dollar bilateral exchange rate has been cointegrated with the relevant consumer price indices. Of the remaining thirty-six currencies, twenty-eight currencies are cointegrated with the consumer prices, the same result is found for wholesale prices. They also show, by the error correction mechanism, that asset markets, not goods markets, affect the necessary adjustment to disequilibrium.

There are also some authors try to investigate the validity of PPP under the special conditions such as high inflation rate and the European Monetary System circumstances. Frenkel (1981) has argued that for countries experiencing high money supply and variable rates of inflation, short-term deviations from PPP will occur, but prices and nominal exchange rate movements will offset each over time so that long-run PPP is likely to hold. If, however,

[10] They are Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the UK and the US.

the economy suffers real shocks, long-run PPP will not hold. Empirical tests for high inflation can be found in Phylaktis (1992), who employs data from Greek drachma during the 1920s when Greece experienced high money supply growth and a high and variable rate of inflation; in McNown and Wallace (1989), who examine four high inflation economies, Argentina, Brazil, Chile, and Israel; in Mahdavi and Zhou (1994), who extend McNown and Wallace's sample to 13 high-inflation countries using quarterly data over the modern floating period. These studies generally find evidence of long-run PPP, but the results are more or less mixed. The authors suggest that, when analysed in conjunction with actual inflation rates in these countries, PPP may hold over a range of inflationary experience, although it is likely to hold more consistently where the inflation rate is very high.

The evidence for the European Monetary System (EMS), which is a system of managed float exchange rates, is analysed by Chen (1995), Cheung, *et al* (1995), Chowdhury and Sdogati (1993), and among others to access how long-run PPP is affected by the EMS exchange rate arrangement. In general, the results of the study support the view that currency realignments of the EMS have been effective in maintaining PPP among its member countries.

However, Edison, *et al* (1997) offer a more sceptical view of the Johansen procedure and have argued that the empirical failure of statistical tests of PPP in post - Bretton Woods data still suffer from the low power of the tests employed. Using critical values estimated by Monte Carlo experiment based on the post - Bretton Woods period for appropriate sample size, they find cointegration for only five out of 13 exchange rates. In three of these five cases the cointegrating vector is not significantly different from PPP. Using the alternative Horvath-

Watson test, a variant of the Johansen procedure that tests directly for a PPP consistent cointegrating vector, they obtained similar results at 5% significance level, but eight of the 13 countries the exchange rates show PPP consistent cointegration at the 10 % level.

Cross country panel data

An alternative way to circumvent the low power of traditional tests has been the use of panel data, and recently a number of competing studies have emerged. They argue that standard unit root and cointegration tests have low power against stationary alternatives in small samples and suggest that failure to support the long-run PPP, as reported by early researchers, may result from this shortcoming. Although some researchers have turned to long time series, as noted before, and find the evidence in favour of a long-run tendency toward PPP, the long samples required for statistical significance are available for only a few currencies. More importantly, the problem arising in using a long time span of data is the ignorance of the changes in exchange rate regimes. As Mussa (1986) pointed out, real exchange rates behave very differently under different exchange rate regimes. If there are different parameters governing fixed versus floating rates, any test may be heavily affected by the inclusion of fixed rate period.

Frankel and Rose (1996) examine deviations from PPP using a panel of 150 countries. The panel shows strong evidence of mean-reversion similar to that from long-run time series. The deviations from PPP have a half-life of approximately four years. The panel approach is also followed in Jorion and Sweeney (1996), Mark (1995), Wu (1996), Oh (1996), Papell and Theodoridis (1998), and Lothian (1997). All report similar findings. Recently, O'Connell

(1998) raises a potentially important problem with this approach. He points out that the standard practice of calculating all real exchange rates relative to the US dollar leads to cross sectional dependence in time series panel data. Adjusting for this problem appears to make it more difficult to reject the random walk null. Taylor and Sarno (1998) also point out that there may exist bias, sometimes a substantial bias, towards stationary in such test.

In summary, the above review shows that although great efforts have been made on the empirical test of PPP, the results are mixed relative to the long-run convergence to PPP. The following lists possible problems arising from testing of PPP,[11] then raises three arguments in the existing literature to the modifications of PPP.

3.4 The problems arising from testing PPP

Construction of the price indices

We have seen that PPP theory is based on the concept of comparing identical basket of goods in two economies. An important problem facing researchers in this aspect is that different countries usually attach different weightings to various categories of goods and services when constructing their price indices. This means that it is difficulty to compare "like with like" when testing for PPP. This factor is probably very significant when testing for PPP between developed and developing economies which have vastly different consumption patterns. People in developing countries usually spend a high proportion of their income on basics such as food and clothing while these take up a much smaller proportion of people's expenditure on developed economies.

[11] For the details see Krugman and Obstfeld (1994) and Pibeam (1992).

Relative PPP does in fact make predictions about price changes rather than price levels, and so is a sensible concept, regardless of the baskets used to define price levels in the countries being compared. However, changes in the relative prices of basket components can cause relative PPP to fail tests that are based on official price indices.

Transport costs and trade impediments

Contrary to the assumption of the law of one price, transport costs and restrictions on trade certainly do exist. These trade barriers may be high enough to prevent some goods and services from being traded between countries. Studies, such as Frenkel (1981), note that PPP holds better when the countries concerned are geographically close and trade linkages are high, which can partly be explained by transport costs and the existence of other trade impediments such as tariffs. Nonetheless, since transport costs and trade barriers do not change dramatically over time they are not a sufficient explanation for the failure of the relative version of PPP.

Imperfect competition

One of the notions underlying PPP is that there is sufficient international competition to prevent major departures of the price of a good in one country exceeding that in another. However, it is clear that there is considerable variation in the degree of competition internationally. These differences mean that multinational corporations can often get away with charging different prices in different countries. Monopolistic or oligopolistic practices in goods markets may interact with transport costs and other trade barriers to weaken further the link between the prices of similar goods sold in different countries.

Relative price of nontradables

The existence in all countries of nontraded goods and services whose prices are not linked internationally allows systematic deviations even from relative PPP. Because the price of a nontradable is determined entirely by its domestic supply and demand, changes in these may cause the domestic price of a broad commodity basket to change relative to the foreign price of the same basket. Other things being equal, a rise in the price of a country's nontradables will raise its price level relative to foreign price levels, or the purchasing power of any given currency will fall in countries where the prices of nontradables rise.[12]

One striking empirical observation that is well documented, see the survey by Rogoff (1996), is that when prices of similar baskets of both traded and non-traded goods are converted into a common currency, the aggregate price indices tend to be higher in rich countries than in poor countries. Further evidence shows that tradable goods prices are nowhere as dissimilar internationally as those of non-traded goods. Consequently the overall higher price index in rich countries is mainly due to the fact that nontradable goods prices are higher in developed than developing countries.

Differences between capital and goods markets

PPP is based on the concept of goods arbitrage and has nothing to say about the role of capital movements. However, as Dornbursh (1976) hypothesised, there can be substantial prolonged deviations of the exchange rate from PPP. The basic idea is that in the short-term, goods prices in both the home and foreign economies can be considered fixed, while the exchange rate adjusts quickly to new information and changes in economic policy. This being the case,

[12] The effects of rising of non-tradables in causing PPP will be further investigated in Chapter 4.

exchange rate changes represent deviations from PPP which can be quite substantial and prolonged.

3.5 Modifications to PPP

Concerning above factors, the studies on long-run PPP typically find less favourable evidence using the post-1973 data, and suggest that PPP deviations are governed by permanent disturbances. To deal with this a number of modifications to the long-run PPP have been put forward. The first considers the empirical regularity that when expressed in terms of a single currency, countries' price levels are positively related to the level of real income per capital. The Balassa-Samuelson theory explains this regularity by postulating that the labour force in the tradable sector of poor countries is less productive than that in rich countries, but that international productivity differences in nontradables are negligible. Assuming that prices of traded goods are more or less the same, the lower labour productivity in the tradeables industry in poor countries implies lower wages there than abroad and thus lower price levels of nontradables. There is substantial empirical support for the Balassa-Samuelson hypothesis, especially in comparisons between very poor and very rich countries, but often empirical results are mixed. It seems hold for the yen-dollar rate but not for the other industrialised country exchange rates, see Rogoff (1996), and Mark and Choi (1996), where productivity differentials are found to improve the forecasting performance of the Japanese yen-dollar rate and the Canadian dollar -US dollar rate.

Another explanation for long-run deviations from PPP is that the real exchange rate changes are due to sustained imbalances of the current account, that is, sustained current account deficits are associated with long-run real exchange rate depreciation. For example, Hooper and Morton (1982), and Obstfeld and Rogoff (1995) show, empirically, that there does appear to be some correlation between these two variables over five to ten years horizons. These correlation, of course, does not imply causation. Kurgman (1990) argues that current accounts are likely to induce significant real exchange rate changes because they lead to transfers of wealth across countries; and home and foreign residents are likely to exhibit varying spending patterns, a redistribution will give rise to changes in the long-run real exchange rate. Hence, the causation of the relation between the exchange rate and the current account can go both ways, which remains a subject of debate on an empirical matter.

Finally, the level of government spending can be argued to adjust PPP. Froot and Rogoff (1991), for example, find that among EMS countries, government spending is a significant determinant of the real exchange rate. He explains this effect as that relative to private spending, government spending tends to fall more heavily on non-traded goods. Hence an increase in government spending leads an appreciation in the real exchange rate more than an equivalent rise in private spending. However, one can question whether this demand effect is permanent. Rogoff (1996) argues that such effect must be transitory because demand shocks can affect the real exchange rate in a small country only to the extent that capital and labour are not perfectly mobile across sectors. Over the long-run, with free capital movements the real exchange rate will be determined by differences in productivity and other supply side shocks. Mark and Choi (1997) find that the inclusion of government spending in the regression improves the forecasts of the bilateral rate between the Japanese yen and the US dollar, and the Canadian dollar and the US dollar.

Apart from the above three modifications to PPP, pricing to market factor may also be important in governing long-run deviations from PPP, for example, see Feenstra and Kendall (1997), Marston (1990), and Faruqee (1995). Sometimes, monopolistic firms limit international arbitrage of prices by refusing to provide warranty service in one country for goods purchased in another. To the extent that prices can not be arbitraged, then of course producers can price discriminate across the different international markets. Krugman (1987) refers to such price discrimination as "pricing to marker". Knetter (1989, 1993) and Kasa (1992) find pricing to market is important across a surprising large range of goods. Because pricing to market is possible only when goods market arbitrage is blocked, it seems more likely to be an important factor in the short to medium run than in the long-run.

3.6 Conclusion

In this chapter the PPP theory and the recent literature on testing PPP have been reviewed. In modern models of exchange rate dynamics, PPP is a key element since it is supposed as a long-run equilibrium condition. However, as it has been surveyed, although many studies have tried to verify, by using the recently advances of time series analysis, whether exchange rates follow the path outlined by the PPP equation, the empirical results, at least, are inconclusive. Econometric studies, applying unit root or cointegration tests to post-1973 data, typically cannot reject the hypothesis that the real exchange rate is nonstationary, and therefore, reject the PPP hypothesis. On the other hand, studies that extend data over longer time spans, or use cross-section of currencies, tend to support for the PPP hypothesis. However, long time series ignores the regimes change in exchange rate, while panel data fails to control for cross-sectional dependence, and has a bias towards stationary process.

Several reasons have been given in the literature for the failure of the PPP or deviation of the PPP, including lack of free trade; existence of transaction costs and nontradables; different weights used in constructing different national price indexes; different movements between asset and goods markets; and existence of real factors or real variables. Among these reasons, real factors have been received most of the attention in the literature, especially the productivity bias. In the next chapter, it will concern the theory of the factors driving exchange rate movements and governing long-run real exchange rates, and explore how these real factors might cause the permanent changes in real exchange rates.

Chapter 4

Purchasing Power Parity: Real Disturbances

• Introduction

The incompleteness of the purchasing power parity (PPP) theory to fully account for exchange rate movements was first recognised by Cassel (1922). One of the major insights of Cassel was that the PPP theory only holds if the sources of the price disturbances are monetary. In other words, the PPP theory predicts that when a monetary shock occurs, for example, an increase in the money stock, both the domestic price level and the exchange rate will increase in the same proportion. The PPP theory, however, does not predict that when a real shock occurs, the proportionality between the price level and the exchange rate will be maintained. There are several reasons that the real factors may drive exchange rate movements and govern long-run real exchange rates. In particular, since the real exchange rate is defined as the nominal exchange rate adjusted for the general or overall price differentials between two economies, shocks that affect the relative price of tradables and non-tradables will, in theory, bias the validity of PPP and cause the permanent changes in real exchange rates. In what follows we investigate the sources of trend movements of real exchange rates. In section 4.1 the importance of relative prices of non-tradables to tradables which might cause the permanent changes in the real exchange rate is analysed in detail. Then the focus is turned to investigate the possible sources that might cause such changes in the equilibrium of relative prices, with section 4.2 on supply side and section 4.3 on demand side. In section 4.4 an empirical model is developed on long-run equilibrium real exchange rate incorporating these real factors and recent studies on real factors are reviewed. The final section 4.5 provides the conclusion.

4.1 The role of relative price of non-tradables

PPP relies on the existence of arbitrage of goods and services between the domestic and foreign economies. If the price difference between two countries becomes large, arbitrage opportunities should occur to prevent unbounded price movements. Thus, the existence of profitable opportunities of trade should ensure the existence of a long-run equilibrium. In this case, PPP holds and the real exchange rate follows a stationary process.

If non-traded goods exist, however, there is no reason to expect PPP to hold for all goods in the long-run. Non-traded goods are those that cannot be traded internationally at a profit, such as houses and services, and have prices determined by domestic supply and demand, while traded goods are ones that are susceptible to the international competition, such as most manufactured goods, prices of which are determined by international markets. Hence, the prices of non-traded goods may diverge substantially across countries, without an effective arbitrage mechanism to ensure price equality. Increases in the foreign price of non-traded goods are unlikely to be matched by equivalent domestic price increases. Since the innovations in these price indices may affect real exchange rate movements, it is important to consider their role.

First, consider an aggregate price index which is made up of both traded and non-traded goods. Let p_t be the broad price level, which is a weighted average of the prices of traded goods and non-traded goods:

$$\begin{aligned} p_t &= (1-\alpha)p_t^T + \alpha p_t^{NT} \\ &= p_t^T + \alpha\,(p_t^{NT} - p_t^T) \\ &= p_t^T + \alpha\,\rho_t \end{aligned} \tag{4.1}$$

where α denotes the shares of non-traded goods in the economy; p_t^T is the price of traded goods; p_t^{NT} represents the price of non-traded goods; and ρ_t ($= p_t^{NT} - p_t^T$) is known as the relative price of non-tradables. Suppose further that a similar relationship exists for the prices in the foreign country:

$$\begin{aligned} p_t^* &= (1-\alpha^*)p_t^{T*} + \alpha^* p_t^{NT*} \\ &= p_t^{T*} + \alpha^*\,(p_t^{NT*} - p_t^{T*}) \\ &= p_t^{T*} + \alpha^*\,\rho_t^* \end{aligned} \tag{4.2}$$

where "*" denotes the foreign economy. All of the variables are in logarithms.

Second, defining the real exchange rate as the nominal exchange rate adjusted for the overall price differentials between two economies gives:

$$q_t = s_t - p_t + p_t^* \tag{4.3}$$

where s_t is the logarithm of the nominal exchange rate, defined as the number of units of domestic currency per unit of foreign currency; q_t represents the logarithm of the real exchange rate, and gives the price of foreign goods in terms of domestic goods. Therefore, a rise (fall) in q_t denotes, in this case, a real depreciation (appreciation) of the domestic currency.

Finally, substituting equations (4.1) and (4.2) into equation (4.3) yields the following:

$$q_t = (s_t - p_t^T + p_t^{T*}) - \alpha(p_t^{NT} - p_t^T) + \alpha^*(p_t^{NT*} - p_t^{T*}) \tag{4.4a}$$

or $$q_t = (s_t - p_t^T + p_t^{T*}) - \alpha\rho_t + \alpha^*\rho_t^* \tag{4.4b}$$

equation (4.4) highlights the potentially important sources of long-run real exchange rate variability and indicates that the real exchange rate can be decomposed into four components:

- $(s_t - p_t^T + p_t^{T*})$: the relative price of traded goods in the two countries
- $(p_t^{NT} - p_t^T)$: the relative price of nontradables in domestic country
- $(p_t^{NT*} - p_t^{T*})$: the relative price of nontradables in foreign country
- α and α*: the weights of the non-traded goods sectors in the overall price index

If the "law of one price" applies to tradable goods, then the first component can be taken as zero.[1] Further assuming that the weights α (α*) are constant over time,[2] then, a general expression for the long-run equilibrium real exchange rate can be expressed in terms of tradable and nontradable goods prices,

$$q_t = -\alpha(p_t^{NT} - p_t^T) + \alpha^*(p_t^{NT*} - p_t^{T*}) \tag{4.5a}$$

or $$q_t = -\alpha\rho_t + \alpha^*\rho_t^* \tag{4.5b}$$

[1] However, the constancy of the real exchange rate defined with respect to traded goods is not uncontroversial. For example, there is now considerable evidence to suggest that the kinds of goods produced by industrial countries are not perfect substitutes and therefore the idea that price differences are quickly arbitraged away is completely unrealistic, see Engle (1995) and Wei and Parsley (1995). However, Canzoneri *et al* (1999) argue that Engle's conclusion might be sensitive to the choice of reference currency. Using DM exchange rates, they find the evidence that is considerably more favourable to purchasing power parity in traded goods. Since the emphasis here is to illustrate the role of traded and non-traded goods, we ignore this effect at the moment.

[2] It is widely accepted that the weights used to construct overall price series differ across countries. Often in PPP calculations such differences are assumed constant across countries and therefore in a relative PPP calculation, or indeed when looking at the time series properties of the real exchange rate, they do not matter. Since the evidence on the relative importance of this effect is unclear, therefore we do not explicitly model the time variability of the α weights.

It is clear from equation (4.5a,b) that the distinction between traded and non-traded goods plays an important role in explaining real exchange rate dynamics. It shows that the real exchange rate is a function of the relative price of nontradables in the domestic and foreign economies respectively. Permanent changes in these relative prices in either country will result in permanent change in the real exchange rate. It is also clear from equation (4.5a,b) that real exchange rate movements induced by non-traded goods relative price changes will be significant if (i) non-traded goods comprise a large sector of the goods included in the price index; and (ii) non-traded goods relative prices move differently across countries. Thus, relative price changes can cause deviations from PPP, i.e. changes in ρ_t or ρ_t* that are not offsetting between two economies will cause PPP violation and non-stationarity of the real exchange rate. For example, suppose that α is similar to α*, then a rise in the domestic price of non-tradable goods relative to tradable goods by a bigger portion than that the foreign one will lead to an appreciation (fall) of the home currency, represented by a fall in q_t, as PPP holds only in terms of tradable goods. On the other hand, an increase in the relative price of foreign nontradables implies a real depreciation of domestic currency, represented by a rise in q_t. Therefore, testing for PPP using price indices based on tradable goods prices is likely to lead better results than when using aggregate price indices made up of both types of goods.

The assumption of PPP hold for tradable goods leads to the condition that the real exchange rates depend on the relative price of traded in terms of non-traded goods, exchange rate movements induced by changes in relative prices between tradable and non-tradable goods represent real exchange rate changes. Among the factors that can lead to such relative price changes is, the most commonly cited one, the different rates of productivity in the traded and non-traded sectors between the economies, which is known as the Balassa-Samuelson effect. We will explore various factors which may lead to such relative price changes from both supply and demand sides in detail in the next sections.

4.2 Supply side shocks and the real exchange rate

Productivity differentials

The Balassa-Samuelson model (Balassa 1964, Samuelson 1964) shows that positive innovations to traded productivity lead to increases in the relative price of non-tradables, which cause real exchange rate appreciation.[3] They argued that in a fast-growing economy, productivity growth in the traded goods sector tends to be higher than in the non-traded goods sector (relative to the differential in the rest of the world). They assumed that the "law of one price" holds for traded goods, that wages in the tradable goods sector are linked to productivity and that wages across industries are equal, and therefore that the relative price of non-traded goods tends to rise. These assumptions cause the price of non-tradable goods relative to tradable goods to increase more over time in a country with high productivity growth in the tradable goods sector than in a country with low productivity growth. Such a productivity differentials will result in a real exchange rate appreciation for fast growing countries even with the prices of traded goods equalised across countries. This hypothesis does require stringent conditions that capital is perfectly mobile internationally, and that forces of production are free to move between sectors. To explain movements in the relative price of non-tradables, it assumes a competitive market where firms set prices to reflect unit labour costs (nominal wages adjusted for productivity) in each sector:

[3] The review of the Balassa-Samuelson theory is given by Asea and Corden (1994).

$$p_t^T = w - a_t^T ,\ p_t^{NT} = w - a_t^T \tag{4.6a}$$

$$p_t^{T*} = w^* - a_t^{T*},\ p_t^{NT*} = w^* - a_t^{NT*} \tag{4.6b}$$

where a_t^T (a_t^{NT}) represent productivity in traded (non-traded) goods, and w the wage rate, which is equalised across sectors due to labour mobility. Productivity differentials, defined as non-traded minus by traded productivity, explain movements in the relative price of non-tradables:

$$p_t^{NT} - p_t^T = a_t^T - a_t^{NT},\ p_t^{NT*} - p_t^{T*} = a_t^{T*} - a_t^{NT*} \tag{4.7}$$

Substitution of equation (4.7) into equation (4.5a) yields:

$$q_t = - \alpha(a_t^T - a_t^{NT}) + \alpha^*(a_t^{T*} - a_t^{NT*}) \tag{4.8}$$

Productivity innovations in the traded good sector imply lower traded goods prices and appreciation of real exchange rates. If these innovations are persistent, departures from PPP will be long lasting.

The Balassa-Samuelson theory assumes that the labour forces of poor countries are less productive than those of rich countries in the tradables sector but that international productivity differences in nontradables are negligible. If the prices of traded goods are roughly equal in all countries, however, lower labour productivity in the tradable industries of poor countries implies lower wages than abroad, lower production costs in non-tradables and therefore a lower price of nontradables. Rich countries with higher labour productivity in the tradables sector will tend to have higher nontradables prices and higher price levels. Productivity statistics give some empirical support to the Balassa-Samuelson differential productivity postulate, see Martson (1987). And it is plausible that international productivity differences are greater in traded than in non-traded goods.

It is clear that PPP based on tradable goods alone will undervalue the purchasing power of people in poor countries, because they can purchase more non-traded goods per dollar than can people in rich countries, even if PPP holds for traded goods. This means that when comparing per capita income levels between a poor country and the United States in dollar terms this should not be done at the PPP rate for tradable goods. Rather, the proportion of poor country's expenditure on non-tradables should be valued at US non-tradable prices thereby raising the value of poor country's income in US dollar terms.

Although the Balassa-Samuelson model can help explain why PPP does not necessarily hold in terms of aggregate price indices, it is only a partial explanation as it cannot explain the failure of PPP to hold for traded goods, so we need to consider some other possible explanations.

World real price of oil

Link between the price of oil and the real exchange rate has been noted by Krugman (1983), McGuirk (1983), and more recently, Throop (1993), Amano and Norden (1995, 1998), Chaudhuri and Daniel (1998) and a number of other researchers. The importance of this variable was highlighted by the dramatic increase in the real price of oil in the 1970s and the equally dramatic fall in the mid-1980s. The changes in the real price of oil can have an effect on the relative price of traded goods, usually through their effect on the terms of trade. Countries which make a transfer (the oil consuming countries) will experience a real depreciation of their currency, as they experience a deficit in their current account and have to build up a surplus on non-oil trade to pay for the higher oil bill. They realise this surplus by a real depreciation, either by a nominal depreciation (for a given domestic price level), or by a reduction of domestic spending, which will improve the non-oil trade balance. By the same token, this expenditure reducing policy will tend to reduce the domestic price level relative to the price level in the oil producing country and the domestic currency will experience a real depreciation.

The influence of the price of oil on the bilateral real exchange rate relies on the difference between the two relevant countries in their dependence on imported oil. If one county is self sufficient in oil and the other not, the currency of the former would appreciate in terms of the other currency as the price of oil rose. In general, an increase in the real price of oil causes deterioration in the trade balance and a reduction in aggregate demand of an oil importing country. As a result, the real value of the country's currency is expected to depreciate to restore equilibrium in the goods market. However, it could find its currency appreciating relative to a country which is even more dependent on oil imports.

Other factors

Changes in tastes and factor endowments have been cited as other factors that influence relative prices and cause purchasing power disparities (Kravis and Lipsey 1983; Bhagwati 1984). The amount of technological innovation is also important to the supply of goods, their price, and ultimately the real exchange rate. If the technological innovation in the home country advances at a pace more rapid than that in the foreign country, the per unit cost and thus the price of home goods should decrease at a faster rate than that of the foreign country and the real exchange rate should depreciate.

4.3 Demand side shocks and the real exchange rate

The Balassa-Samuelson effect assumes perfect competition and instant mobility of capital and labour. If these assumptions do not hold, demand side factors may also be important to affect the relative price of non-tradables and the real exchange rate in the short- and median-run, see Rogoff (1992) and DeGregorio and Wolf (1994). Such factors can be captured by government spending shocks, terms of trade shocks, and changes in traded/non-traded preferences, etc.

Fiscal policy (Government spending)

Changes in the composition of government spending between traded and non-traded goods can affect the long-run equilibrium real exchange rate in different ways.[4] Additional tax-financed spending on non-traded goods, for example, creates incipient excess demand in that market, requiring a real appreciation to restore equilibrium. In contrast, tax-financed increases in spending on traded goods put downward pressure on the trade balance, and a real depreciation is required to sustain the external balance. However, government spending can reasonably be assumed to be mostly on non-tradables, and such changes in government spending could raise the price of non-traded goods relative to traded goods. As a result, its effect on the real exchange rate is similar to that of productivity differentials, i.e. leading to the domestic currency appreciation.

Terms of trade

An improvement in the terms of trade is expected to lead to an appreciation in the equilibrium exchange rate. A positive terms of trade shock (an increase in the price of

[4] See Grauwe (1996) and Frenkel and Razin (1992) for the details on fiscal policies and the real exchange rate.

exports relative to the price of imports) causes the output in the nontradables to decline, creating excess demand in the non-traded goods sector, which results in a real cxchange rate appreciation.

Preferences

Another demand side concern is the rising preferences for services as income rises, which means consumer preferences shift toward non-traded goods. Genberg (1978) has demonstrated that if the income elasticity of demand for non-traded goods is greater than unity, the relativc price of non-traded goods will rise as income rises. This relative price change will be reinforced if, as seems likely, the share of government expenditure devoted to non-traded goods is greater than the share of private expenditure, and if income is redistributed to the government over time. This variable can be captured by GDP per capita or per capita income.

4.4 Equilibrium real exchange rates

In the above sections, it has analysed various shocks which may violate the validity of PPP, and which, in turn, may cause the permanent changes in the real exchange rate. When incorporating these real factors, the equilibrium real exchange rate can be expressed as the following function,

$$q_t = F(\overset{-}{prod_t}, \overset{-}{tot_t}, \overset{-}{gs_t}, \overset{+}{gs_t^*}, \overset{-}{pf_t}, \overset{+/-}{Poil_t}, \overset{+/-}{ofs_t}) \tag{4.9}$$

where $prod_t$ is a measure of productivity differentials in the traded goods sector between the home and foreign countries; tot_t denotes the effect of the terms of trade; gs_t and gs_t* represent domestic and foreign government spending variables, respectively; pf_t captures the effect of preferences; $Poil_t$ is the world real price of oil; and ofs_t represents other factors. For the reasons shown above, a rise in the domestic value of any variable, excluding the oil price and foreign government spending, will generate an appreciation of the overall real exchange rate (a fall in q_t). A rise in foreign government spending will cause domestic currency depreciation (a rise in q_t) and the effect of the change of oil price depends on the relative oil resources of the two countries. The signs above the variables indicate the corresponding changes.

The question of whether relative productivity growth alone can explain the behaviour of real exchange rates has been previously examined.[5] Most early published studies that focus on relative productivity as a determinant of exchange rates rely on cross-sectional regression rather than time series analysis and the results are mixed. Balassa (1964) constructs $(P_i / P_{us}S)_i$ (a measure of deviation from PPP) for 12 industrial countries for the year of 1960 and regresses it on real per capita income (as a measure of productivity) of each country. With 12 cross-sectional observations he obtains a highly significant positive coefficient. He then concludes that the empirical results provide evidence of a positive relationship between purchasing power parities, exchange rates, and per capita income levels. Other cross-sectional studies provide mixed support for the hypothesis. Among them, the early studies are De Vries (1968), Clague and Tanzi (1972), Grunwald and Salazar-Carillo (1972), and Officer (1976), who do not support the hypothesis; and more recent studies include Kravis and Lipsey (1978, 1983), who do support the hypothesis.

[5] See Froot and Rogoff (1994) for the survey of the early work.

Recently, the publication of the OECD's detailed sectoral databases sparks a resurgence in this work, focusing on the time series data,[6] which includes Hsieh (1982), Marston (1987), Edison and Klovland (1987), DeGregorio, Giovannini and Wolf (1994), Strauss (1995, 1996), and Dutton and Strauss (1997). Some of the studies are based on the Balassa-Samuelson hypothesis and focus on the effect of supply side factors, but several other studies introduce some type of rigidity, such as adjustment costs of re-allocating factors of production between sectors, so that demand side factors also determine the real exchange rate.

Hsieh (1982) is the first to look at the time series data and he supports for the hypothesis.[7] He studies the US bilateral exchange rates with Japan and Germany from the year 1954 to 1976 and finds that the productivity differential variables, using labour productivity, are significant and of the correct sign for both real exchange rates. He concludes that the real exchange rate changes can be explained by differences in the relative growth rates of labour productivity between traded and non-traded sectors for these countries and their trading partners.[8]

[6] The classification of sectors is fairly arbitrary, with differences among the studies. Hsieh (1982) equates the tradable goods sector with manufacturing and treated GDP other than manufacturing as nontradables. Marston (1987) defines agriculture and manufacturing as tradables and defines construction and all other services except electricity-gas-water as nontradables; mining and electricity-gas-water are excluded from his analysis because of a desire to abstract from products with a high energy contents. Edison and klovland (1987) define agriculture, mining, manufacturing, construction, and electricity as commodity sector (tradables) and all services except construction and electricity-gas-water as services sector (nontradables).
[7] Hsieh argued that the fact that these time series support the productivity bias hypothesis or explain the variation in real exchange rates better than most cross-sectional regressions could be due to country specific factors which are held constant in time series studies but not in cross-sectional studies.
[8] One limitations of Hsieh's empirical work is the use of lagged difference data, which ignores both the issues and associated problems of integrated variables as well as the implications of long-run equilibrium behaviour between domestic and foreign productivity and real exchange rates.

Marston (1987) employs disaggregated data to investigate the extent to which departure from PPP is caused by the presence of non-traded goods, as against deviations from the law of one price in traded goods. He looks at the yen/dollar real exchange rate over the period 1973-1983, and calculates traded and non-traded goods productivity differentials using OECD data that disaggregates the economy into ten sub-sectors. Using sector employment data, Marston calculates labour productivity differentials between traded and non-traded goods, and argues that these variables provide an extremely plausible explanation of the long-run trend real appreciation of the yen against the dollar. Edison and Klovland (1987) examine the time series data on the exchange rate between the British pound and Norwegian krone for the years 1874-1971 and find significant evidence of a productivity differential effect using both the real output differential and a measure of the commodity/service productivity ratio differential.

DeGregorio, Giovannini and Wolf (1994) use the Balassa-Samuelson model to investigate why non-tradable inflation has been more rapid than that for tradables for a sample of 14 OECD countries during the period 1970-85. They present a cross-country panel regression that attempts to determine the relative importance of demand and supply factors. They construct measures of productivity growth in the traded and non-traded sectors for fourteen OECD countries and twenty sectors. On the demand side, they test for the effect of real government spending over real GDP and real per capita income on the relative price of nontradables. Their results show that productivity, government spending and income variables are all highly significant and of the theoretically predicted signs. In order to see whether demand factors matter in the long-run, they average data for each country over time and run a regression for the cross-section data and find that the productivity differentials remain extremely significant whereas demand factors (government spending and income) become less important. They point out that demand side factors will affect the real exchange rate only if the assumption of perfect competition, PPP for traded goods, or perfect capital mobility are relaxed.

DeGregorio and Wolf (1994) pursue this last line of inquiry. Using the same data as in DeGregorio *et al* (1994), they present a model that nests the productivity model of Balassa-Samuelson, so that supply and demand shocks have an effect on the real exchange rate. They then estimate a number of first difference specifications which include terms of trade effects, government spending shocks and the income levels and use total factor productivity as their productivity measure. They find that the terms of trade are important empirically, although productivity differentials and government spending continue to be important. Relative incomes, however, become insignificant when terms of trade shocks are included. They conclude that the income variable in the above regression may be proxying for terms of trade shocks.

More recently, with the advances in econometric techniques for analysing non-stationary series, several studies have appeared in the existing literature to test whether there exists the long-run relationship between the real exchange rate and fundamentals. Cointegration is one such development and is appropriate in this case, since the presence of cointegration between two or more series, as defined by Engle and Granger (1987), can be interpreted as evidence of a stable long-run relationship.

Using the Engle-Granger procedure, Baillie and Selover (1987), Baillie and McMahon (1989), and Kim and Enders (1991) provide evidence that there are no long-run relationships between bilateral nominal exchange rates and so-called fundamentals. However, more recent studies adopting Johansen (1988) and Johansen-Juselius (1992) maximum likelihood method tend to support the existence of such long-run relationships. While some authors investigate whether a link exists between the real exchange rates and some specific factors, others explore whether a group of factors, or fundamentals, causes the permanent changes in the real exchange rate. Examples of studies of single factor including In and Menon (1996), who test the terms of trade shock and show that the real exchange rate and the terms of trade of the 7 major OECD countries are cointegrated in the long-run, Amano and Norden (1995, 1998), Chinn and Johnston (1996) and Claudhuri and Daniel (1998), who find an significant relationship between the real exchange rate and the real price of oil and suggest that the oil price fluctuations play an important role in exchange rate movements.[9] Two works by Dutton and Strauss (1997) and DeLoach (1996) test the impact of non-traded goods relative price movements on real exchange rates. Dutton and Strauss (1997) construct the relative price of non-tradables using two different data sets for the post-Bretton Woods period: one consists quarterly CPI data for 13 OECD countries and other consists monthly CPI for Canada, France, Japan, the UK and the US. In general, both data sets follow the same classification into traded/non-traded categories, that is, manufacturing goods are considered traded and services are classified as non-traded. Using the Johansen-Juselius cointegration method, they report the results that for all countries except Denmark and

[9] Amano and ven Norden (1998) focus on the effect of oil prices on a country's terms of trade, while Chaudhuri and Daniel (1998) focus on real exchange rates measured in the produced price index. However, it is not obvious, argued by Chaudhuri and Daniel, that a panel approach, as in Chinn and Johnston (1996), should imply cointegration between real exchange rates and oil prices since an oil price increase should have different effects in different countries.

Norway using quarterly data and the UK using monthly data, the null hypothesis of no cointegration among the real exchange rate and non-traded goods relative price is rejected at 10% significant level. A rise (fall) in the domestic relative price of non-traded goods is associated with an appreciation (depreciation) in the real exchange rate while the opposite is true for the foreign relative price. Further, they explore the relationship between domestic and foreign relative prices and find these two variables are not cointegrated, which means that relative prices move differently across countries and these movements influence real exchange rate behaviour. According to their results, they claim that non-traded goods relative price movements are linked to the movements in the real exchange rate and are important sources of persistent deviations of the real exchange rate away from its PPP value. Nevertheless, DeLoach's results are far from conclusive. He reports that only seven of twenty-one cases support the underlying theory. However, as the author explains, the proxy for the ratio of traded to non-traded goods price (using ratio of CPI to WPI) may be inadequate.

Examples of the multi-factor shocks can be observed in the papers by Dibooglu (1996), Zhou (1995), MacDonald (1997), and Feyzioglu (1997), etc. These authors construct the models which incorporate the real factors in determining the long-run equilibrium real exchange rates. The most frequently incorporated factors are the world real price of oil, the domestic and foreign fiscal variables, and the differentials of productivity growth.

Dibooglu (1996) directly tests a modified version of PPP, that is, PPP is augmented by real supply (productivity in the tradeables sector and world real price of oil) and demands (real government spending) disturbances, using Johansen's cointegration procedure and quarterly data from the post Bretton Woods period for Germany, Italy and Japan vs. the United States and testing the comovement among several variables, that is, the bilateral exchange rates, national price levels, productivity, government spending and real oil price. The null hypothesis of no cointegration is rejected for all countries. Moreover, productivity, government spending and real oil price are jointly significant for all the countries. The results imply that the data is not favourable to a mean reverting, stable real exchange rate, and productivity, government spending and real world oil price shocks might have caused systematic deviations from PPP in the post - Bretton Woods period.

Zhou (1995) tests the long-run relationship between the real exchange rate and the fundamental variables such as productivity, government spending and the real world oil price. Except for these shocks, he further incorporates the monetary variable into the model. The currencies he studies are the real Japanese yen and the real Finish markka, both against the US dollar. Zhou finds that changes in real variables have a significant and persistent influence on the variation of both real rates while the monetary disturbances have only short-lived effects. MacDonald (1997) constructs the model of the real effective exchange rates of the dollar, the mark, and the yen which is implemented with two components: a real interest rate differential and a set of fundamentals including net foreign asset accumulation, productivity bias, and fiscal balances. He concludes that fundamentals do have an important and significant bearing on the determination of both long- and short-term exchange rates. Feyzioglu (1997) incorporates the terms of trade, the real interest rate and productivity into the model to study the Finland real effective exchange rate. He reports that all of the above factors affect the real exchange rate in the long-run. In all, the above empirical tests based on the industrial countries all support the evidence that there are long-run relationship between real exchange rate and real fundamentals.

Although extensive studies investigate the real disturbances which could cause the permanent changes of real exchange rates, none of these studies are able to satisfactorily validate any of the standard models of exchange rate determination. Moreover, all of the inquires are on the industrialised nations, especially on OECD countries with the availability of detailed sectoral databases. Few give evidence on developing countries, especially the East Asia economies, partly because of the problems inherent in constructing accurate time series on relative sectoral productivity levels. There are limited studies focusing on East Asian region. Such example can be seen in Bahmani-Oskooee and Rhee (1996), Isard and Symansky (1996), Ito *et al.* (1997) and Chinn (1996, 1997), with mixed results. Bahmani-Oskooee and Rhee (1996) focus on only the Korea currency. They test cointegrating relation between real exchange rate and productivity differentials between Korea and four of major Korea trading partners (US, UK, Japan, Germany). They report the evidence of cointegration between real exchange rate and productivity differentials, and the positive coefficient on productivity differentials, thus supporting Balassa-Samuelson hypothesis. Isard and Symansky (1996) study the real exchange rates for Asia Pacific Economic Cooperation Council (APEC) region, allowing the nontraded shares (α's) to change over time. They break the real exchange rate changes into three components: (i) changes in the relative price of traded goods; (ii) changes in the relative price of traded to nontraded goods; (iii) and changes in share weights (α's). They obtain the results that the first term accounts for almost all of the movements in the real rate for China, Indonesia, Japan, the Philippines, and Thailand. Chinn (1996) examines East Asian exchange rates (including China, Indonesia, Japan, Korea, the Philippines, Singapore and Thailand related to the US) in this accounting sense, adopting a single-equation error correction modelling approach. He finds, somewhat in contrast with Isard and Symansky (1996), that there is some evidence that in the long-run relative prices of tradables and nontradables do explain real exchange rates, at least for some currencies.

4.5 Conclusion

In this chapter, it has demonstrated the role of the relative price of non-traded to traded goods in explaining the real exchange rate movements. It has been shown that if the 'law of one price' applies to tradable goods, real exchange rate is a function of the relative price of nontradables in the domestic and foreign economies respectively. Permanent changes in these relative prices in either country will result in permanent changes in the real exchange rate. It has also investigated some potential factors that may lead such relative price changes, among them are productivity differentials, the world real price of oil and government spending. The relationship between these factors and real exchange rates has also been explored. Literature has confirmed linkages between real factors and real exchange rates. Whether this linkages exist for the East Asian cases merits further inquires, which turns to next chapters.

Chapter 5

The Econometric Approaches to PPP

• Introduction

This chapter discusses the contemporary econometric approaches used to examine the purchasing power parity (PPP) hypothesis. There are two basic methods in testing for the PPP condition: one is to focus on the stochastic behavior of real exchange rate, based on the advances in the statistical theory of unit root tests; and the other is to test for the comovement between the nominal exchange rate, domestic price and foreign price by using the cointegration techniques. Both methods involve the analysis of non-stationarity of data and both of them have implications for the study of the long-run PPP. This chapter is organised as follows. In section 5.1, the unit root test of real exchange rates is outlined as it is essential to the testing of PPP. In section 5.2, the concept of cointegration, especially the implications and the relationships between cointegration and PPP are introduced and explored in details, which is the center to the present study. The discussion of the econometric testing procedures are provided in section 5.3 and the final section 5.4 goes to the conclusion.

5.1 Random walk hypothesis of real exchange rates

The PPP hypothesis states that, in the absence of trade impediments, speculation, central bank intervention, and other impediments to trade, the nominal exchange rate should tend to equalise relative prices between two countries, that is,

$$s_t = p_t - p_t^* \qquad (5.1)$$

where s_t is the nominal exchange rate; p_t is the price of a bundle of goods expressed in the domestic currency; and p_t* is the price of a bundle of goods expressed in the foreign currency. All of the variables are in logarithms.

Further, the real exchange rate, q_t, can be defined as,

$$q_t = s_t - p_t + p_t^* \qquad (5.2)$$

which is the nominal exchange rate adjusted for the domestic and foreign prices. From equation (5.2), it is clear that PPP has specific implications for the time series behavior of real exchange rate, that is, real exchange rate should never change, at least not permanently. Consequently, one approach in testing for PPP is addressed by examining the stochastic behavior of the real exchange rate. Such tests seek to determine whether the real exchange rate behaves as a random walk. A variable is said to follow a random walk if its value in the next period equals its value in the current period plus a random error that cannot be forecast using available information. On the other hand, the rejection of null hypothesis means that real exchange rate is stationary.

In the context of PPP, random walk behaviour means that the real exchange rate is the outcome of a sequence of real shocks, each of which permanently alters the level of the real exchange rate. That is, there is no tendency for the real exchange rate to return, however slowly, to its mean or trend. If this is the case, PPP is rejected, since at a minimum it requires the real exchange rate to fluctuate about some constant term. If the real exchange rate follows a random walk, it will not return to some average value associated with PPP over time. In other word, its deviation from the PPP value becomes unbounded in the long-run. On the other hand, rejection of the null hypothesis implies that the real exchange rate appears to fluctuate about a fixed mean with a tendency to return to it. It would be evidence in favour of long-run PPP, since it would imply that deviations of real exchange rates from its mean value are only temporary.

The standard unit root test is a common technique in econometrics to determine whether a variable follows a random walk. It is to test the null hypothesis that a series does contain a unit root. If the existence of a unit root can not be rejected, then the variable is said to follow a random walk. The procedures commonly used are DF and ADF tests. The ADF accounts for temporally dependent and heterogeneously distributed errors by including lagged innovation sequences in the fitted regression. Both are popular either because of their simplicity or their more general nature. More recently, the Phillips and Perron (1988) unit root tests has been adopted, which accounts for non-independent and identically distributed process using non-parametric procedure. Since the ADF relies on parameter procedure to correct for autocorrelation and heterogeneity, the Phillips-Perron test is often favoured over the ADF in term of its power.

An alternative is the variance ratio test. If a series follows a random walk, then the variance of the *kth* difference of a non- stationary series increase with k. However, if a series is stationary, this variance ratio should tend to be zero as k tends to infinity. Both procedures regarding unit root and variance ratio tests will be briefly described in the section 5.3.

5.2 Cointegration, PPP and real exchange rates

Another approach in testing for PPP is to test if the variables in interest constitute a long-run comovement and further to test if the coefficient restriction implied by PPP is valid. Such tests are addressed under the theory of cointegration and we briefly describe it in the following.

5.2.1 Modeling with cointegrated variables

Following Granger (1983), and Engle and Granger (1987), a series y_t is said to be integrated of order d (or $y_t \sim I(d)$) if it needs to be differenced d times to become stationary. Thus, a time series integrated of order zero is stationary in levels, while for a time series integrated of order one, the first difference is stationary. A white noise series and a stable first-order autoregressive [AR(1)] process are examples of I(0) series, while a random walk process is an example of an I(1) series.

The main differences between I(0) and I(1) processes, as discussed by Granger (1986) and Engle and Granger (1987), are as follows. For I(0) series, it (a) has finite variance which does not depend on time, (b) has only a limited memory of its past behavior (i.e. the effects of a particular random innovation are only transitory), (c) tends to fluctuate around the mean (which may include a deterministic trend), and (d) has autocorrelations that decline rapidly as the lag increases. For the case of an I(1) series, the main features are: (a) the variance depends upon time and goes to infinity as time goes to infinity, (b) the process has an infinitely long memory (i.e. an innovation will permanently affect the process), (c) it wanders widely, and (d) the autocorrelations tend to one in magnitude for all time separations.

Consider two time series x_t and y_t which are both I(d) (i.e. they have compatible long-run properties). In general, any linear combination of two series will also be I(d). If, however, there exists a vector β, such that the disturbance term from the regression ($u_t = y_t - \beta_1 x_t$) is of a lower order of integration, I(d-b), where b>0, then Engle and Granger (1987) define y_t and x_t as being cointegrated of order (d, b) or $[y_t, x_t]' \sim CI(d, b)$, while $\beta' = [1, -\beta_1]$ is known as the cointegrating vector.

Thus, if y_t and x_t are both I(1), and if they are cointegrated, there must exist a unique representation :

$$y_t = \beta_0 + \beta_1 x_t + u_t \tag{5.3}$$

such that u_t is a stationary error term, $u_t \sim I(0)$.

From equation (5.3), we can see that cointegration means that the residuals from a linear regression of two or more time series are stationary, which implies that among a group of integrated or non-stationary variables, certain linear combinations can be stationary. The variables being cointegrated do not drift too far apart from one another and there is a long run equilibrium relationship among them.

The economic interpretation of cointegration is: if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends (i.e. be non-stationary) they will nevertheless move closely together over time and the difference between them will be stable. Thus the concept of cointegration tries to mimic the existence of a long-run equilibrium to which an economic system converges over time, as in equation (5.3) where u_t can be interpreted as the equilibrium error (i.e. the distance that the system is away from the equilibrium at any point in time).

Further, it has been shown (Engle and Granger, 1987) that if variables are cointegrated, then there always exists an error correction mechanism (ECM) representation.[1] For example, the error correction representation of equation (5.3) is:

$$\Delta x_t = \rho_1 u_{t-1} + \textit{weighted sum of lagged } (\Delta x_t, \Delta y_t) + \varepsilon_{1t}$$

$$\Delta y_t = \rho_2 u_{t-1} + \textit{weighted sum of lagged } (\Delta x_t, \Delta y_t) + \varepsilon_{2t} \qquad (5.4)$$

with $|\rho_1| + |\rho_2| \neq 0$ and ε_{1t} and ε_{2t} are finite-order moving average processes. Note that the term u_{t-1} in equation (5.4) presents the extent of the disequilibrium between levels of y_{t-1} and x_{t-1} in the previous period.

One of the distinct features of ECM is that it incorporates both short-term and long-run effects. This can be seen by the fact that the long-run equilibrium u_t is incorporated into the model. Thus, if at any time the equilibrium holds, then $(y_{t-1} - \hat{\beta}_0 - \hat{\beta}_1 x_{t-1}) = 0$. During periods of disequilibrium, this term is non-zero and measures the distance the system is away from equilibrium during time t. Thus, the ECM states that change, for example, in y_t is

[1] Banerjee *et al* (1993) show that although the estimates of β_1 in Eq. (5.3) are consistent, there is evidence that small sample bias can be significant. This bias can be reduced by estimating β_1 directly in the dynamic error correction model, given by Eq. (5.4).

due to the immediate, "short-term" effect from the change in x_t and y_t, and the extent of disequilibrium between the levels of y_{t-1} and x_{t-1} based on the cointegration regression, which represents the "long-run" adjustment to the past disequilibrium. The appeal of the ECM formulation is that it combines flexibility in dynamic specification with desirable long-run properties. It could be seen as capturing the dynamics of the system whilst incorporating the equilibrium suggested by economic theory. A second feature of the ECM is that all the terms in the model are stationary, so standard regression techniques are valid.

Equation (5.4) indicates that, if the two series are cointegrated, then either Δx_t or Δy_t (or both) must be caused by u_{t-1} which itself is a function of x_{t-1}, y_{t-1}. Thus, either x_t is caused by y_{t-1} or y_t by x_{t-1}. This follows directly from the error correction model and the condition $| \rho_1 | + | \rho_2 | \neq 0$, as u_{t-1} must be present in at least one equation. So, as Granger (1983) suggests, if a pair of series have an attainable equilibrium, there must be some causation between them to provide the necessary dynamic information. Thus, the knowledge of u_{t-1} must improve forecasting ability of at least one of x_t, y_t.

It is important to note that, in an economic system, there are two kinds of variables, endogenous and exogenous variables. Endogenous variables, or jointly determined variables, have outcome values determined through the joint interaction with other variables within the system. Exogenous variables are variables that affect the outcome of the endogenous variables, but whose values are determined outside the system. In the case of equation (5.4), if ρ_i is insignificant, it implies that the error correction term has no impact on the *ith* variable and so it is exogenous. It drives thc comovements of the variables in thc cointegrated system. On the other hand, a significant ρ_i implies that variable i endogenously reacts to the past errors (deviations from the cointegrating relationship) and adjusts to restore the long-run relationship. Note also that the magnitude of ρ_i provides the information for the speed of adjustment to disequilibrium, that is, it tells how variable y_t (x_t) changes in response to disequilibrium. For instance, suppose that y_t starts to increase less rapidly than is consistent with equation (5.3), perhaps because of a series of large negative random shocks (captured by u_t). The net result is that $(y_{t-1} - \hat{\beta}_0 - \hat{\beta}_1 x_{t-1}) < 0$, since y_t has moved below the steady-state growth path. But since ρ_1 is negative, the overall effects is to boost Δy_t, thereby forcing y_t back towards its long-run growth path as determined by x_t (equation (5.3)).

The above theory has been shown that cointegration is helpful in modelling non-stationary time series. Cointegration describes effectively the characteristics of non-stationary time series and their long-run behaviour and relationships. Moreover, with the ECM term incorporated, it also demonstrates vividly the short-term dynamics of the system, and the way the system deviates from and adjusts to the long-run equilibrium. Therefore, the methodology will help inquire into a number of economic issues, especially with those of a long-run nature, such as the PPP relation. The following section will show the links between cointegration and PPP, and how PPP conditions can be implied by the cointegration relationships among the exchange rate and prices of two countries.

5.2.2 Cointegration and PPP

Economic theory in many cases postulates that the time series representations of economic series should trend together. Structural economic models using standard econometric techniques attempt to model the relationships between series and to estimate the parameters which underlie the relationship. From these parameter estimates, various inferences about the underlying theory can be made. Another way in which trending variables might arise is from the assumption of equilibrium relationships. If it is assumed that equilibrium holds, then it can be seen that the difference between the equilibrium and the actual should not be "large". More generally, it is the case that econometric techniques and /or data limitations may not allow for adequate inference to be drawn. However, by the theory of cointegration, more general and easier inference can be obtained concerning economic theory.

As has been seen in the previous section, cointegration implies that variables do not wander far apart over time, so the difference between them will be stationary. Thus cointegration provides another method in testing for the PPP hypothesis. In the framework of cointegration, PPP is tested by examining whether deviations from the relationship between the nominal exchange rate and price series tend to return to some fixed mean (i.e., are stationary) or whether they wander aimlessly about with no fixed mean (i.e., are non-stationary or contain a unit root). In the content of cointegration theory, the existence of long-run PPP amounts to satisfying two conditions. **First**, and most importantly, there must exist an equilibrium relationship between nominal exchange rate, domestic price level and foreign price level, i.e., they should share a common trend. Formally, suppose these three variables (nominal exchange rate s_t, domestic price level p_t and foreign price level p_t^*) are I(1) series, if there exists a cointegration relationship,

$$s_t = \beta_0 + \beta_1 p_t + \beta_2 p_t^* + u_t \tag{5.5}$$

where u_t is the error term capturing deviations from PPP, this implies a long-run link between three variables. Even if they are non-stationary, they will not drift far apart. This combination has been given the economic interpretation of long-run static equilibrium, that is, the series trend over time, but the equilibrium error of the system will revert to its mean given sufficient time. **Second**, the coefficients β_1 and β_2 should satisfy the conditions of (a) symmetry, $\beta_1 = -\beta_2$, and (b) proportionality, $\beta_1 = \beta_2 = 1$, between the domestic and foreign countries. Thus, defining a vector X_t' as $[s_t\ p_t\ p_t^*]$, if the theoretical vector $\beta' = [\ 1\ -1\ \ 1]$ is contained in the cointegrating space, then the long-run PPP holds, which in turn means that the real exchange rate is stationary.

In this respect, the cointegration test applied to the relationship between exchange rate and relative prices indices differs from the unit root test to the real exchange rate in that it does not impose homogeneity restrictions on prices a priori. The relaxation of parameter restrictions may be a more appropriate test since the homogeneity restriction on price levels may not be reasonable for several reasons including measurement error and/or existence of transportation costs.

MacDonald (1995) suggests a distinction between what he refers to weak-form and strong-form versions of PPP. If a cointegration relationship exists between s_t, p_t and p_t^*, then the weak-form version of PPP holds. Further, if a cointegrating space $\beta' = [1\ -1\ \ 1]$ is found such that $\beta'X_t$ is stationary, where $X_t' = [s_t\ p_t\ p_t^*]$, then the strong-form version of PPP holds, where a long-run relationship as defined above exists as well as degree one homogeneity of the exchange rate with respect to relative prices.

5.2.3 Cointegration and long-run equilibrium real exchange rates

As is mentioned, if the real exchange rate follows a random walk behaviour, then it implies that the real exchange rate is the outcome of a sequence of real shocks and that the series itself is subject to further scrutiny. In this regard, cointegration provides an especially apt framework for evaluating long-run relationships between the real exchange rate and a set of relevant real economic variables. If the fundamentals driving the long-run equilibrium real exchange rate are themselves integrated time series properties, that is, if such variables experience permanent shocks during the sample period, the real exchange rate will tend to be an integrated time series process as well. In this case, if the theory linking the real exchange rate to its fundamental determinants is correct, a cointegration relationship should exist between the real exchange rate and the fundamental determinants identified by the theory. The residual from this cointegrating equation is the gap between the actual real exchange rate and the long-run value predicted by the fundamentals and is itself a stationary proccss.

Thus, it is of great interest to test if there exist cointegrating relationships between real exchange rates and other relevant real economic variables. The presence of cointegration would support the claim that real exchange rate have long-run, stable relations to real factors in the economy that do not diverge arbitrarily far from equilibrium. In testing for weather the real exchange rate and fundamentals constitutes a long-run relationship, the following procedures should be performed. First, the real exchange rate is tested for the presence of a unit root. If the series is trend stationary, then the equilibrium real exchange rate is based on purchasing power parity. If instead the series contains a unit root, then permanent changes in the real exchange rate are assumed to be driven by corresponding changes in some set of its potential fundamental determinants. Because the non-stationary behaviour of the real exchange rate much be driven by non-stationary behaviour in the fundamentals. Thus, the next step is to identify the set of non-stationary fundamentals. This is done by testing the fundamentals individually for the presence of a unit root. Finally, the cointegrating relationships are estimated between the real exchange rate and the relevant subset of the underlying fundamentals. The fitted values of the cointegrating equation for the real exchange rate represent the estimate of the long-run equilibrium real exchange rate, and its residuals measure the gap between the actual and the long-run equilibrium real exchange rates.

Having introduced the aspects in testing for PPP and long-run equilibrium real exchange rate, the next section goes to the testing procedures and their uses in empirical studies of PPP.

5.3 Recent methods in testing for PPP

5.3.1 Testing the random walk hypothesis in real exchange rates

The Dickey-Fuller and Augmented Dickey-Fuller tests

The essential idea of the DF and ADF tests is that if a series, x_t, is stationary (mean reverting), then in an equation such as

$$\Delta x_t = a + (\rho_a - 1)x_{t-1} + v_t \tag{5.6}$$

ρ_a should be significantly less than 1, whereas if x_l follows a random walk, $\rho_a = 1$. This test is equivalent to testing $(\rho_a - 1) = \rho_a^* = 0$ against $\rho_a^* < 0$. In other word, if ρ_a^* is significantly negative, then the series x_t is stationary.

DF test is based on the assumption that a variable follows a simple first-order autoregression, AR(1), such as equation (5.6), and that the disturbance term is independently and identically distributed (iid.). An examination of the residuals from regressions would demonstrate that this is not so for most economic time series. This problem is usually dealt with by modifying the DF tests, that is the ADF test, in which one takes account of any serial correlation present by entering lagged values of the dependent variable in the regression.

The specification of the ADF test is,

$$\Delta x_t = \mu_b + (\rho_b - 1)\, x_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta x_{t-i} + e_t \tag{5.7a}$$

$$\Delta x_t = \mu_c + \beta_c t + (\rho_c - 1) x_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta x_{t-i} + \delta_t \tag{5.7b}$$

where the lag length k is chosen so as to ensure that the residuals are white noise. Equations (5.7a) and (5.7b) are to test whether variable x_t is stationary or stationary around a trend, respectively. The null hypothesis in the ADF test is that x_t is non-stationary or has a unit root. In terms of equations (5.7a) and (5.7b), this implies that estimates of ρ_b and ρ_c in the two equations are equal to one. If the null hypothesis ($\rho_b = 1$ or $\rho_c = 1$) is accepted, then it implies that x_t is a non-stationary series. On the other hand, if the null is rejected, then x_t is a stationary series around a mean (or around a trend). For this hypothesis, the conventional t-statistics on ρ_b (or ρ_c) are used, but the critical values for the t-statistic may not be found in standard statistical tables, as the non-stationarity of x_t under the null causes the distribution to be non-standard. Critical values for the various statistics proposed by Dickey and Fuller have been tabulated by Fuller (1976) and Dickey and Fuller (1981). The ADF (or DF) test may be successively applied to differences of the original series in order to discover the value of d, the order of integration.

The Phillips-Perron procedure

Another approach, an asymptotically equivalent procedure to DF test, for testing the presence of a unit root, is presented by Phillips (1987) and Phillips and Perron (1988), or PP test for short, which is a non-parameteric procedure. The ADF statistics are based upon the assumption that the disturbance term ε_t is identically and independently distributed, which ignores the temporal dependence of the error sequence presented in many simple efficient markets. Unlike the strict iid error assumption of DF test, the conditions imposed on the error sequence by PP test are weak. They suggest amending these statistics to allow for many weakly dependent and heterogeneously distributed innovations. Under such general conditions, a wide class of DGP's for ε_t, such as most finite order ARIMA models, can be allowed.

Phillips and Perron (1988) suggest, rather than taking account of extra elements in the DGP by adding them to the regression model, to account for the autocorrelation that will be present (when these terms are omitted) through a non-parameteric correction to the standard statistics. That is, while the Dickey-Fuller procedure aims to retain the validity of tests based on white noise errors in the regression model by ensuring that those errors are indeed white noise, the Phillips and Perron procedure acts instead to modify the statistics after estimation in order to take into account the effect that autocorrelated errors will have on the results. Asymptotically, the statistic is corrected by an appropriate amount to produce what is known as a Z-statistic and the critical values are identical to those used for the traditional DF tests. The effect is the same as that of ADF-type tests, and one can validly conduct asymptotic inference using the table supplied by Fuller (1979). This procedure does not, however, require the estimation of additional parameters in the regression model.

The advantage of these modified Z-statistics is that, asymptotically they eliminate the nuisance parameters which may be present in the DF statistics when the error are not iid. However, the main drawback in computing these Z-statistics is that the researcher has to decide *a priori* on the number of residual autocovariance which are to be used in implementing the corrections suggested by Phillips and Perron.

Let data generate process (DGP) y_t bc a time series of

$$y_t = y_{t-1} + u_t \tag{5.8}$$

The PP test then involves computing one of three OLS regressions defined from

$$y_t = \rho_a y_{t-1} + u_{at} \tag{5.9a}$$

$$y_t = \mu_b + \rho_b y_{t-1} + u_{bt} \tag{5.9b}$$

$$y_t = \mu_c + \gamma_c (1 - T/2) + \rho_c y_{t-1} + u_{ct} \tag{5.9c}$$

where T denotes the sample size, and the innovation sequence u_{at}, u_{bt}, and u_{ct}, given in assumption 2.1 of Phillips and Perron (1988), could be a stationary ARMA process with time dependent variance. This method provides test statistics for the regression coefficient under the null hypothesis that data is generated by equation (5.8), which are the DF t-statistics adjusted by the factors that account for heterogeneity of the error process.

Variance ratio test

One disadvantage of unit root tests is that they have relatively low power when used to test against alternatives of near stationary behaviour (See Cochrane 1988, Campbell and Perror 1991). A better way of picking up long autocorrelations may be to use the variance ratio test, Cochrane (1988). This test uses the insight that if a series does indeed follow a random walk (the null hypothesis) then the variance of the *k*th difference of the series should equal k times the variance of the first difference. Thus, if real exchange rate does follow a random walk then the variance of $\Delta q_{t-k} = q_t - q_{t-k}$, where k >1, should equal k times the variance of $\Delta q_{t-1} = q_t - q_{t-1}$, and so

$$V_k = \frac{1}{k}\frac{Var\,(q_t - q_{t-k})}{Var\,(q_t - q_{t-1})} = 1 \tag{5.10}$$

where V_k denotes the variance ratio, based on lag k. Lo and MacKinlay (1988) have demonstrated that the variance ratio is asymptotically equal to 1 plus a weighted average of the first k-1 autocorrelation coefficients of q_t-q_{t-1}. If the average of these autocorrelations is zero, V_k will be unity. If, however, there is a preponderance of negative autocorrelations this will produce a value of V_k less than one and the real rate will display mean version. Conversely, if positive autocorrelations predominate this will give a value of V_k above one and we have super-persistence — a tendency for the series to cumulatively move above the mean. The key insight of the variance ratio is that it may be necessary to include a large number of autocorrelations to pick up mean-reverting behaviour and standard unit root tests of persistence based on short-term ARMA models may fail to do so.

5.3.2 Cointegration test

The Engle-Granger two-step method

The Engle-Granger two-step test, which is based on the ordinary least squares, is the original test for cointegration. The test applies either the standard or the augmented DF test for a unit root to the residual from the first stage 'cointegrating regression' of the levels of the variables. For the PPP studies, if $X_t' = [s_t, p_t, p_t^*]$ and each series is non-stationary, or has a unit root (i.e. they are I(1)), the first step is to run the cointegrating regression as equation (5.11),[2] using the logarithms of the exchange rate and domestic and foreign price series,

$$s_t = \beta_0 + \beta_1 \, p_t + \beta_2 \, p_t^* + u_t \tag{5.11}$$

[2] It depends on the specification being used. If homogeneity condition is assumed, that is $\beta_1 = \beta_2$, then the cointegration regression is

$$s_t = \beta_0 + \beta_1 \, (p_t - p_t^*) + v_t$$

From equation (5.11), we can get the residual series u_t. Then the second step is to test whether the residual, u_t, is I(1), i.e. whether the residual has a unit root. If the residual series rejects the null of I(1), then the series used in equation (5.11) are cointegrated. They constitute a long-run stable relationship.

An alternative test for cointegration can be performed using an error correction model. The error correction representation theorem (Granger, 1983) states that for cointegrated series there exists an error correction representation:

$$\lambda(1-L)X_t = \phi u_{t-1} + \varepsilon_t$$

where (1-L) is the difference operator, λ contains the coefficients of the dependent and explanatory variables; $\phi \neq 0$, and u_{t-1} is the "equilibrium error" or "error correction mechanism". The error correction representation of equation (5.11) is:

$$\Delta s_t = \gamma + \phi u_{t-1} + \lambda_1 \Delta p_t + \lambda_2 \Delta p_t^* + v_t \tag{5.12}$$

The error correction may include lagged differences of short-term, p_t and p_t* to correct for any series correlation in the error term v_t. Cointegration demands that the coefficients on u_{t-1} be non-zero. An inability to reject ϕ=0 means that the exchange rate and the domestic and foreign price series are not cointegrated. Kremers *et al* (1992) recommend this test because of the implicit common factor restriction in the DF and ADF tests.

In the error correction representation, the adjustment of the levels of the exchange rate and domestic and foreign prices to their long-run equilibrium relationship is captured in u_{t-1}. The short-term dynamics are captured by the deviations of the variables (Δ) from their means. Since the error correction model comprises stationary variables, classical inference can be conducted.

This Engle-Granger two-step procedure is convenient because the dynamics do not need to be specified until the error-correction structure has been estimated. However, it possesses certain potential limitations. First, large finite-sample biases can arise in static single-equation OLS estimates of cointegrating vectors. While these estimates will be super-consistent, Banerjee, Hendry and Smith (1986), using Monte Carlo experiments, found that large sample sizes may be required before the biases become minimal.

Another limitation is concerned with the number of cointegrating combinations that may exist between a set of variables. While there may be up to n-1 cointegration vectors in an n variables system, the Engle-Granger procedure can only give one. For this reason, the Engle-Granger method has been applied primarily for bivariate systems. The final drawback of the Engle-Granger method is its inability to test inferences about the parameter estimates.

Fractional cointegration tests

Fractional cointegration test of PPP applies fractional integration analysis to the cointegrating regression residual (or equilibrium error) between the exchange rate and the domestic and foreign price series.[3] Fractional integration test contains a broader range of alternative hypothesis to the unit root hypothesis. The alternative hypotheses admit integration order less than one but greater than or equal to zero. A series that is integrated of order d where 0< d<1 is fractional integrated. Consequently, fractional integrated series

[3] See, for example, Cheung and Lai (1993), Gil-Alana (1998), Soofi (1998), Dueker (1993).

exhibit reversion to a mean, but at a much slower rate than a stationary series. Moreover, the covariance may or may not be stationary depending on the magnitude of d. Fractional cointegration also provides information about the percentage of a permanent or real shock that is responsible for keeping the series away from its mean after x periods.

The Johansen-Juselius procedure

Johansen's multivariate cointegration method (Johansen and Juselius, 1990) is based on the maximum likelihood procedure. The method is preferred over the two-step regression method of Engle-Granger in several respects. First, instead of assuming that there exists a unique cointegrating vector between variables, Johansen's procedure explicitly tests for a number of cointegrating vectors. Second, it treats all the variables as endogenous and, thus, avoids an arbitrary choice of the dependent variable as in the cointegrating equations of Engle-Granger tests. Third, Johansen's maximum likelihood method fully captures the underlying time-series properties of the data, and allows for interactions in the determination of the relevant economic variables. Finally, the procedure also permits hypothesis testing of the parameters.

Johansen sets his analysis within the following framework. Defining a general polynomial distributed lag model of a vector of variables X_t as:

$$X_t = A_0 + A_1 X_{t-1} + ... + A_k X_{t-k} + u_t \qquad t = 1, ..., T \qquad (5.13)$$

where X_t is a vector of n variables of interest, each A_i is an nxn coefficient matrix, and u_t is an independently identically distributed (iid) n-dimensional vector with zero mean and covariance matrix Ω. If the elements of X_t are non-stationary, it would seem natural to express equation (5.13) in first difference form. However, as noted in Johansen and Juselius (1990), it is also necessary to apply the difference operator to the error process, otherwise differencing implies a loss of information in the data. The vector error correction model (VECM) form of equation (5.13) is:

$$\Delta X_t = \mu_0 + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-1} + \varepsilon_t \tag{5.14}$$

where

$$\Gamma_i = -(I - A_1 - \ldots - A_i) \qquad i = (1, \ldots, k\text{-}1)$$

and $\Pi = -(I - A_1 - \ldots - A_k)$

Now (5.14) is a traditional first difference VAR model except for the term ΠX_{t-1}, which contains information on both the short- term and long-run adjustment to changes in X_t, via the estimates of $\hat{\Gamma}_i$ and $\hat{\Pi}$, respectively. Now the main task is to investigate whether the coefficient matrix Π contains information about long-run relationships between the variables in the vector.

The rank of the coefficient matrix Π, the matrix which contains information concerning the long-run relationship between the variables in X_t, is equal to the number of cointegrating relations denoted by r. There are three possible situations:

(i) Rank(Π) = n, the matrix Π has full rank, implying the absence of stochastic trends in the data, so the vector process X_t is stationary;

(ii) Rank(Π) = 0, the matrix Π is the full matrix and (5.14) corresponds to a traditional difference vector process, implying there are no stationary long run relationships among the elements of X_t ;

(iii) $0 < \text{rank}(\Pi) = r < n$, implying that there exist r linear combinations of X_t that are stationary or cointegrated.

If condition (iii) prevails, then Π can be decomposed as two $n \times r$ matrices α and β such that $\Pi = \alpha\beta'$, where β is the matrix of long-run coefficients which represent r linear cointegrating relationships such that $\beta' X_t$ is stationary even though X_t itself is non-stationary. Thus, the term $\beta' X_t$ embedded in (5.14) is equivalent to the error correction term $(y_{t-1} - \hat{\beta}_0 - \hat{\beta}_1 x_{t-1})$ in equation (5.4), except that $\beta' X_{t-1}$ contains up to n-1 vectors in the multivariate model. The loading matrix α represents the error correction parameter which can be interpreted as speed of adjustment towards the estimated equilibrium state, such that a low coefficient indicates slow adjustment and a high coefficient indicates rapid adjustment. In this case equation (5.14) can be interpreted as error correction model as Granger (1986) and Engle and Granger (1987). The hypothesis of cointegration is formulated as the reduced rank of the Π-matrix

$$H_1(r): \quad \Pi = \alpha \beta'$$

The likelihood ratio test statistic for the hypothesis that there are at most r cointegrating vectors is

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i)$$

where $\hat{\lambda}_i$ is the estimated values of the characteristic roots (or eigenvalues) obtained from the estimated Π matrix; T is the number of the usable observations. This is what has become known as the trace statistic which is to test the null that the number of distinct cointegrating vectors is less than or equal to r against a general alternative. Another test is the so called the maximal eigenvalue or λ_{max} statistic,

$$\lambda_{\max} = -T\ln(1-\hat{\lambda}_{r+1})$$

This is to test the null that the number of cointegrating vectors is r against the alternative of r+1 cointegrating vectors.

Under the Johansen and Juselius (1990) approach, the maximum likelihood estimation of equation (5.14) permits the testing of hypotheses concerning the number of cointegrating vectors, as well as specific linear restrictions on these vectors. Although the decomposition of $\Pi = \alpha\beta'$ is not unique, the space spanned by the columns of β can be estimated. Thus, a testable hypothesis is whether β can be spanned by at least r vectors of dimension n. Additionally, tests can be performed to determine whether a specific vector is contained in the cointegration space. This latter test is of particular importance in this study since it permits a determination of whether the real exchange rate $s_t - p_t + p_t^*$ is stationary, that is, whether the theoretical PPP vector [1 -1 1] is contained in the cointegration space. This test is conducted by using the following likelihood ratio statistic of Johansen and Juselius (1990), where the null hypothesis is that PPP vector is contained in the cointegration space,

$$-2\ln Q = -T\sum_{i=1}^{r}\ln\{(1-\hat{\lambda}_i^*)/(1-\hat{\lambda}_i)\}$$

where $\hat{\lambda}_i^*$ and $\hat{\lambda}_i$ are the calculated eigenvalues from the restricted and unrestricted models, respectively. These likelihood ratio statistics have an asymptotic χ^2 distribution, with degrees of freedom being equal to the number of restrictions times the number of cointegrating vectors.

The Johansen-Juselius method is now commonly used in multivariate settings. However, the results are often sensitive to the number of lags used in estimation. Typically, researchers will experiment with different lag lengths to ensure that the results are robust. Also, the method often produces parameter estimates of A that are quite large and may seem at odd with a priori hypotheses.

5.4 conclusion

Recent advances in econometric modelling offer important opportunities to the test of validity of the PPP hypothesis. The cointegration, unit root and variance ratio tests have all become common in the literature. The PPP hypothesis can be investigated by testing if the real exchange rate follows a random walk process, often addressed as univariate test. The random walk behaviour of real exchange rate implies the rejection of PPP. The PPP hypothesis can also be tested by cointegration technique, or multivariate test. In the framework of cointegration test, PPP is explored by testing if the exchange rate, domestic and foreign prices form a long-run comovement, and by further testing if the PPP vector, i.e. (1, -1,1), is contained in the cointegration space. This test in fact implicitly relaxes the restrictions of symmetry and proportionality involved in testing for the random walk hypothesis of real exchange rates, and thus it becomes a popular method in testing for the PPP hypothesis.

If the real exchange rate exhibits a random walk behaviour, it implies that the real exchange rate is the outcome of a sequence of real shocks and then the real exchange rate itself is subject to further scrutiny. Thus, it opens up new areas of study by investigating other factors leading to the departure of the real exchange rate from the PPP equilibrium path. Specifically, if a cointegrating relationship can be found between real exchange rate and fundamentals, one can obtain a consistent estimate of the long-run equilibrium real exchange rate without prior knowledge of the full dynamics of adjustment.

Regarding to the test procedures, unit root approaches including DF (or ADF) test, Phillips-Perron test, or alternatively, the variance ratio test are all used to test for a random walk hypothesis of real exchange rates; while cointegration methods including Engle-Granger and Johansen's tests are used to test for the long-run comovement between the nominal exchange rate, domestic and foreign price levels. The Engle-Granger two-step procedure based on ordinary least squares estimation is the simplest test, but it suffers from a number of disadvantages. Johansen's method is based on the maximum likelihood procedure and enables us to find more than one cointegration vector when there are more than two variables. Moreover, it enables us to test for restrictions on cointegration vectors in the system, which is a considerable advantage compared to the Engle-Grange two-step procedure.

In the following chapter the PPP hypothesis will be empirically tested using both unit root test and cointegration procedure.

Chapter 6

Exchange Rate and Price Levels in the Long-run

• Introduction

The previous chapters displayed the modern econometric development in testing for PPP and reviewed the recent literature on PPP and its extensions. In this and the following chapters it will present some empirical evidences concerning the behaviour of exchange rates during the recent float period for seven East Asian countries. This chapter starts with the empirical test for the simple PPP, that is, the nominal exchange rate adjusted for the relative price levels between two countries. By beginning with simple PPP it provides a general picture on the behaviour of exchange rate and price levels and the way of how these series being connected with each other. Section 6.1 starts with presenting data preliminary analysis, followed by graphical evidences concerning the PPP relationship in section 6.2. Then in sections 6.3 and 6.4, the econometric techniques, including the unit root, cointegration and error correction model, are performed for testing PPP. Section 6.5 goes to the conclusion.

6.1 Data preliminary analysis

First of all, we face the problem that has long been existed and still remains, concerning the choice of a reasonable index to present price and describing changes in relative inflation. The chosen index numbers should be easily accessible, frequently reported, and measure the relative movements in inflation for goods and services in foreign trade. There is no index which is perfect for the purpose of PPP and choice is usually between the GDP deflator index, the consumer price index (CPI), as well as the wholesale price index (WPI) or production price index (PPI). Although the GDP deflator provides the broadest coverage of goods and services, it is difficult to obtain figures more frequently than once a year for some of the sample country. In addition, this implicit index contains a high proportion of non-traded goods. WPI or PPI has a broad coverage and has proved to be a good compromise choice. Examination of the way in which the index is computed, however, reveals difference between the methodologies used to compile this index in different countries. For example, for countries like Japan and Singapore, manufactured goods are the major traded goods, but for countries like the Philippines and Thailand, it is agricultural products that are the major traded goods. In the case of Indonesia, the WPI data exclude petroleum products. Hence it would be difficult to find close or similar index for different countries unless they have similar economic structure.

Compared with the wholesale price index, the consumer price index includes many more goods and services that do not form part of the trade between countries. Since the weight of tradables in the basket is higher in WPI than in CPI, from the theoretical point of view, PPP is expected to hold up using WPI better than using CPI.[1] If one is only interested in establishing PPP then WPI would be a appropriate choice for a price measure in the two countries.[2] However, the division between tradables and non-tradables is not completely exogenous and absolute. In the long-run, a considerable part of non-tradable goods and services may eventually become tradable through competition from various substitutes and technological changes. On the other hand, since consumer bundles might be more similar

[1] See Officer (1976) for a discussion of the issues.
[2] Dutton (1998) provides a comparison by using CPI and WPI proxies in testing for the PPP hypothesis.

across countries than producer or wholesale bundles, CPI may provide a more consistent measure of price levels and thus of the real exchange rate. Overall, given that there is little agreement in the literature over which index should be used, this study chooses CPI, as at least it is relatively easy to get for all of the countries.[3]

Data for CPIs and nominal exchange rates, based on the monthly observations, are taken from the IMF's International Financial Statistics (IFS) data bank. The CPIs used are, with 1990 as the base year, seasonally unadjusted, so the potential problem concerning discretionary effects of seasonal adjustments on unit root tests (Ghysels, 1990) can be avoided. The bilateral real exchange rate, q_t, is defined as the price of foreign goods in terms of domestic goods and is measured as the nominal exchange rate adjusted to the domestic and foreign overall price indices, where the price indices are measured by CPIs. As a consequence, an increase in the real exchange rate means domestic currency depreciation in real terms.

The sample period varies for each of the countries and depends on when they adopted a floating or managed floating exchange rate regime.[4] Consequently, the sample period spans 1973:1 to 1996:12 for Japan, Singapore and Malaysia, 1979:1 to 1996:12 for Indonesia, the Philippines, and Thailand, and 1980:1 to 1996:12 for Korea. So there are 288 observations for Japan, Singapore and Malaysia, 216 observations for Indonesia, the Philippines, and Thailand and 204 observations for Korea. The exchange rates used are all bilateral US dollar exchange rates of the Indonesian rapiah, Japanese yen, Korean won,

[3] Rogoff (1996) states that Balassa-Samuelson effect could be much noticeable when real exchange rates are measured by CPIs rather than WPIs.
[4] The details of exchange rate arrangement for each country is given in Appendix 2.

Malaysian ringgit, Philippine peso, Singapore dollar and Thai baht. Table 6.1 presents some descriptive statistics for the data, and the following gives a broad view of these three kinds of data.

Nominal exchange rates

There had been large movements in exchange rates during the sample period.[5] Panel A in Table 6.1 shows that the Philippine peso experienced the largest changes among seven currencies, with the average monthly change being 0.82 percent (9.84 percent annual). It is also the most volatile one compared with other currencies, evidenced by the standard deviation which is 4.31 percent around the mean value. The next most changeable rate is the Indonesian rapiah, with the average monthly change being 0.69 percent (8.28 percent annual) and the standard deviation 4.29 percent. The Japanese yen, Korean won, Malaysian ringitt, Singapore dollar and Thai baht appear more stable compared with the above two, for example, the average change of the Singapore dollar is -0.23 percent (-2.76 percent annual) and the standard deviation 1.57 percent.

Inflation rates

As for the inflation rate, different countries have different average levels.[6] It is obvious that among the seven countries, two are high-inflation countries: Indonesia and the Philippines; and four are low-inflation countries: Japan, Malaysia, Singapore and Thailand. Korea is somewhere in between. The Philippines had not only the highest inflation rate during the period but also the most volatile one among the seven countries, with the average monthly

[5] The plots of series for each countries have been given in Chapter 2.
[6] The details of inflation rate for each country have been described in Chapter 2 with plot of each graph.

change being 1.02 percent (12.2 percent annual) and the standard deviation 1.25 percent. The next highest inflation country, Indonesia, had an average monthly rate of 0.76 percent (9.1 percent annual). Japan and Singapore had the lowest inflation rates among the seven countries, with a mean value of 0.35 percent (4.2 percent annual) and 0.32 percent (3.8 percent annual), respectively. As far as Korea is concerned, inflation was high during the early 1980s, soaring to more than 25 percent in 1980 before setting down in 1993. After 1983, inflation seemed to be under control. During the whole sample period, the average rate was about 6.6 percent per year.

Real exchange rates

As far as the real exchange rate is concerned, the most important feature is its relative turbulence for all countries throughout the period. Panel C in Table 6.1 presents summary statistics for the monthly changes of bilateral real exchange rates. Observing the standard deviation, volatility of real exchange rates ranges from 1.79 to 4.26 percent monthly. In fact, the Indonesian and Philippine rates had the highest standard deviations, and the Malaysian and Korean exchange rates the lowest over the sample period. The signs of mean value of the real exchange rates also show that Japan and Singapore were on an appreciation path against the US dollar on average over the sample period, since the mean values are negative for these countries. In contrast, Indonesia, Korea, Malaysia, the Philippines and Thailand were on a depreciation path.

Table 6.1 Summary statistics of the data

Panel A Monthly changes in nominal exchange rates (in percentages)

Country	Mean	Std Error	Maximum	Minimum
Indonesia	0.69	4.29	44.64	-4.28
Japan	-0.28	3.38	10.34	-11.65
Korea	0.28	1.91	19.47	-4.70
Malaysia	-0.02	1.67	8.19	-8.84
Philippines	0.82	4.31	38.76	-11.86
Singapore	-0.23	1.57	7.25	-8.81
Thailand	0.13	1.75	17.22	-4.99

Panel B Inflation-Monthly changes of CPI (mean unadjusted, in percentages)

Country	Mean	Std Error	Maximum	Minimum
Indonesia	0.76	0.85	4.69	-0.61
Japan	0.35	0.75	4.07	-1.08
Korea	0.55	0.75	4.38	-0.87
Malaysia	0.37	0.56	3.23	-1.52
Philippines	1.02	1.25	8.96	-1.70
Singapore	0.32	0.84	4.96	-1.63
Thailand	0.46	0.67	3.63	-0.98
US	0.46	0.36	1.77	-0.48

Panel C Monthly changes in real exchange rates (in percentages)

Country	Mean	Std Error	Maximum	Minimum
Indonesia	0.33	4.26	41.75	-6.38
Japan	-0.16	3.50	10.00	-13.01
Korea	0.08	1.79	15.99	-5.38
Malaysia	0.06	1.74	7.90	-8.22
Philippines	0.20	4.05	39.68	-12.31
Singapore	-0.09	1.82	6.69	-9.21
Thailand	0.06	1.85	16.93	-5.08

As one of the main objectives of this study is to test the validity of PPP, i.e. if the real exchange rate series exhibits a mean reversion process, the patterns of real exchange rate movements are extremely important and need to be analysed in great detail. From the visual (see Chapter 2) and preliminary data analysis shown above, two important features stand out. First is the relative turbulence of all the series throughout the period, as shown by the standard deviation with highest one being 4.26 and the lowest one 1.79 percent around mean value per month. Indeed exchange rates have been *excessively* volatile when compared with some form of bench-mark, such as the fundamental determinants, especially the relative price levels predicted by the PPP theory. PPP states that the equilibrium exchange rate is determined by the ratio of the domestic and the foreign price levels. If, for example, the foreign price level increases (or decreases) by x percent and the domestic price level by y percent, the equilibrium exchange rate will increase (or decrease) by y-x percent. However, it can be seen that during the period of floating exchange rates the exchange rate movements are much large than the inflation differentials by comparing the volatility of inflation with the real exchange rate. The exchange rates varies month to month roughly 1.87-5.05 times as much as the price of consumer goods and services. It is obvious that the real exchange rate is excessively volatile compared to the inflation for all of the economies. This phenomenon is in fact a centre theme of present study.

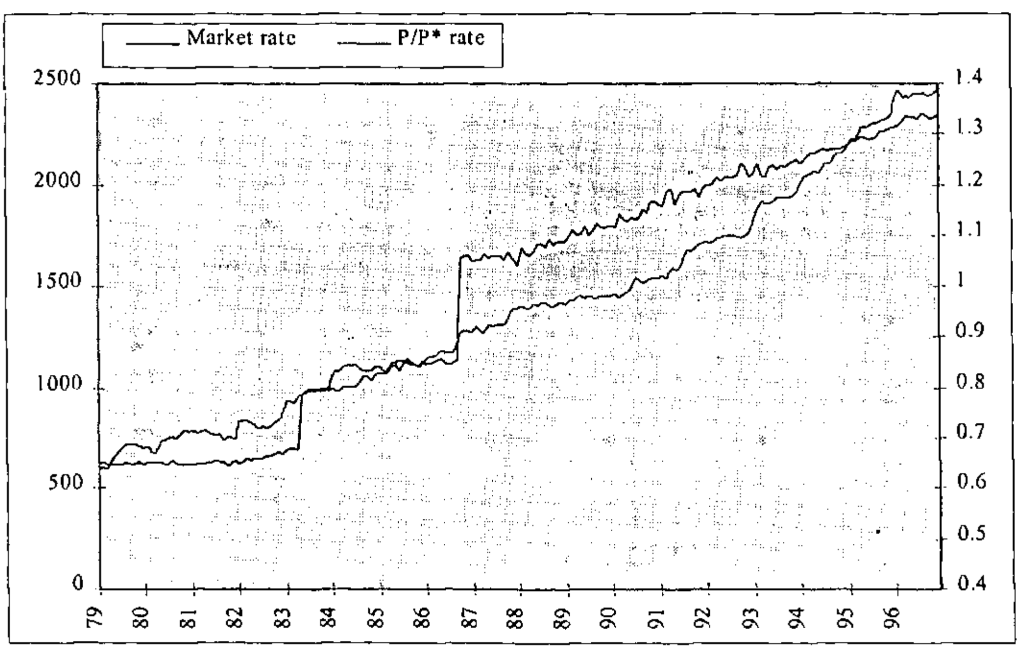
Another important feature is the upward trend in the real exchange rate for all the countries shortly after the floating of the rates and then a downward trend approximately started around 1985. This means nearly all of the currencies appreciated against the US dollar after the mid-1980s. This real exchange rate appreciation observed in the figures might support the Balassa-Samuelson hypothesis as the countries experienced fast growth since then.

6.2 Graphical evidence on PPP

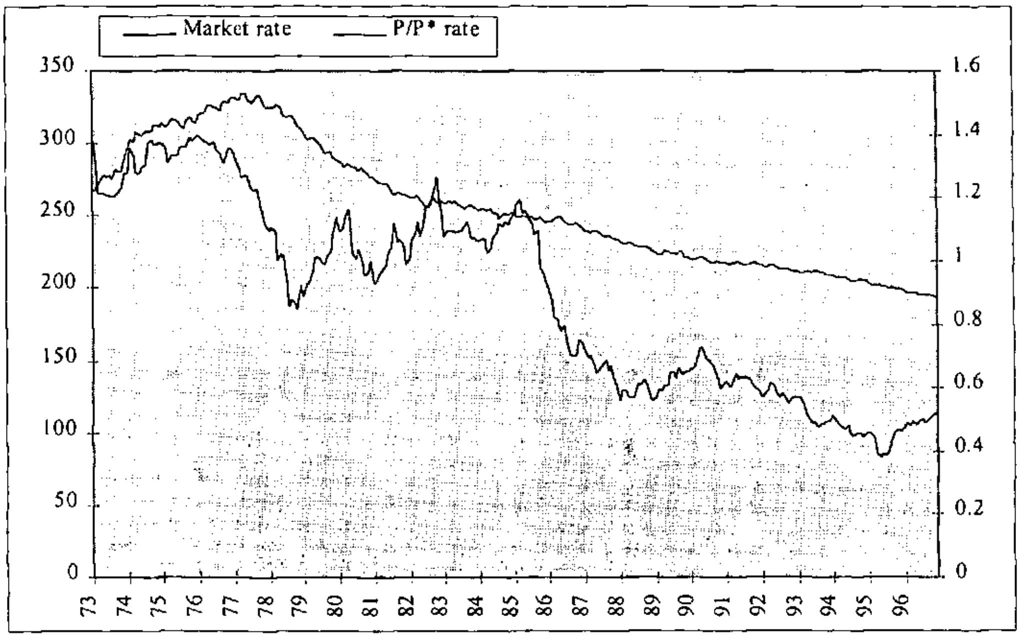
Before applying the econometric techniques to the PPP test, we first present some graphs relevant to PPP relationship, that is, the actual rate and PPP rate, which would provide rough glance on how PPP works. Figures 6.1 (a)-(g) show the actual exchange rate (called market rate), and the exchange rate that would have maintained PPP, that is, the relative domestic-US prices (called PPP rate). For most of the currencies it is noticeable that there are lengthy periods in which exchange rates track relative prices reasonably well and, in particular, there are often relatively long periods in which the trend behaviour of the two series are very similar. However, there are also currencies and periods for which the correspondence does not appear close.

Specifically, Figure 6.1 (a) shows that PPP does all right in tracking the Indonesia rapiah up to 1983. Thereafter, however, the rapiah becomes substantially undervalued in relation to PPP, and this under-valuation becomes even bigger and sustains after 1987. With the Japanese yen, the Philippine peso and the Singapore dollar, it seems that all rates trace PPP reasonably well, although there are brief periods of deviation from PPP. For the Korean won, the Malaysian ringitt and the Thai baht, PPP seems do not do well in tracking these exchange rates from time to time, with both sustained and marked departures from PPP which, nevertheless, have frequently been reversed to the PPP relationship eventually. Moreover, it is quite often for several years, that PPP rates move in the opposite direction from the exchange rates. For example, the Korea won in Figure 6.1 (c) shows that before 1982 PPP does all right but between 1982-89, there is a dramatic depreciation of the won while PPP would have predicted a appreciation. Afterwards, it leads to the restoration of PPP in 1989, but the situation lasts only a short time. After 1991 won becomes overvalued in relation to PPP.

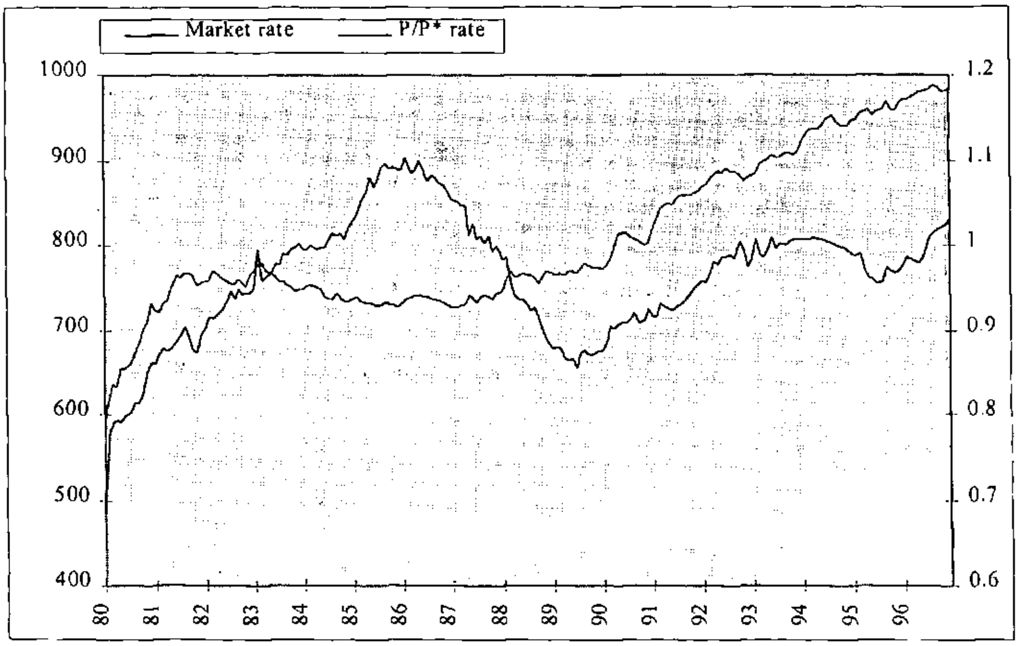
Figure 6.1 Nominal exchange rate and PPP rate



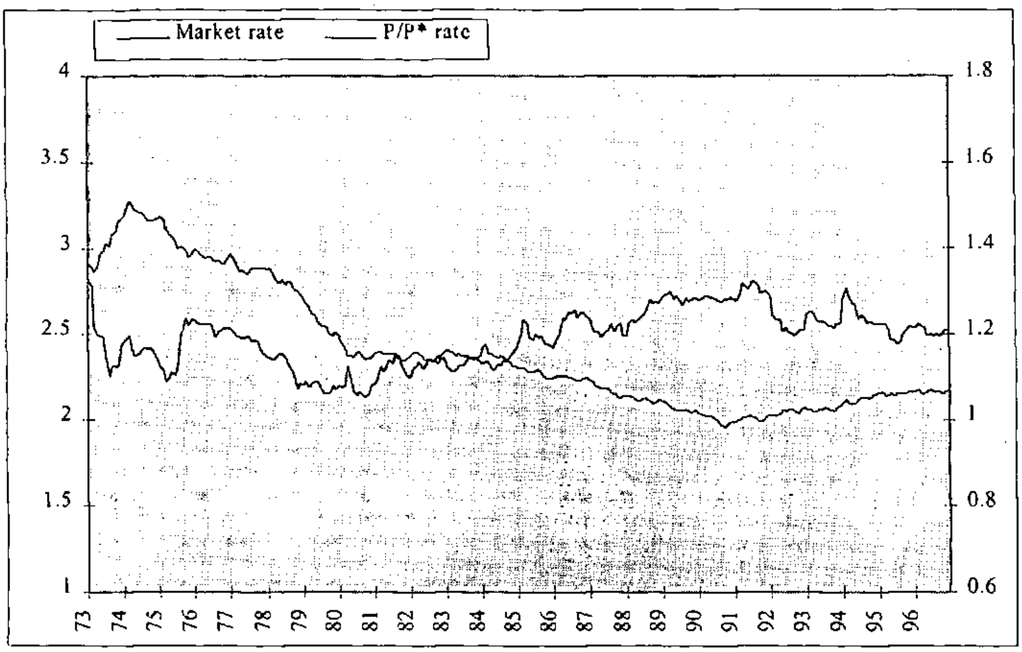
(a) Indonesia



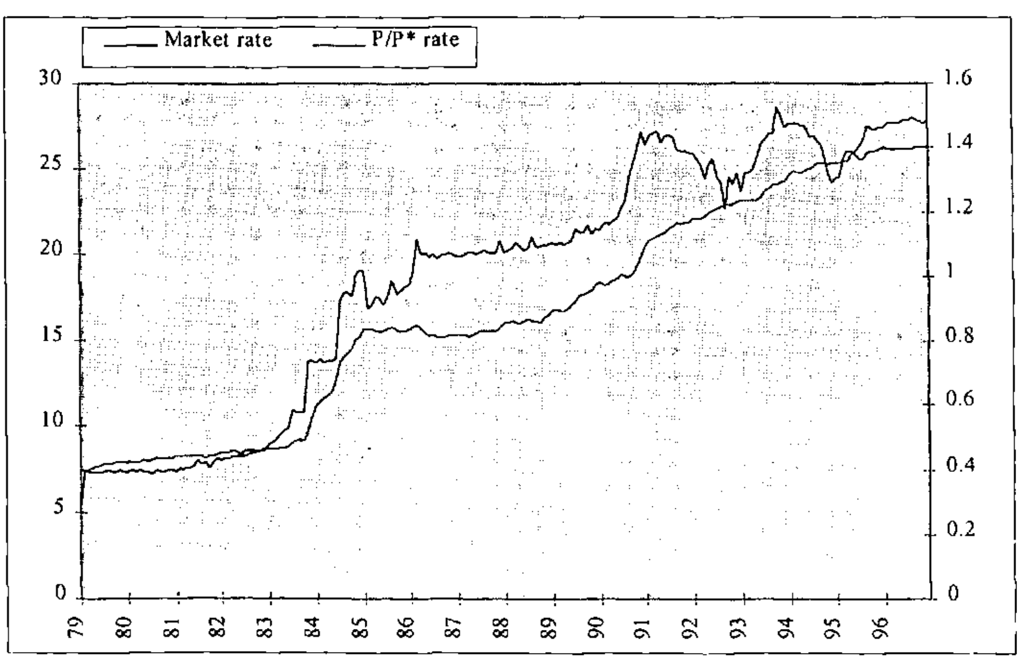
(b) Japan



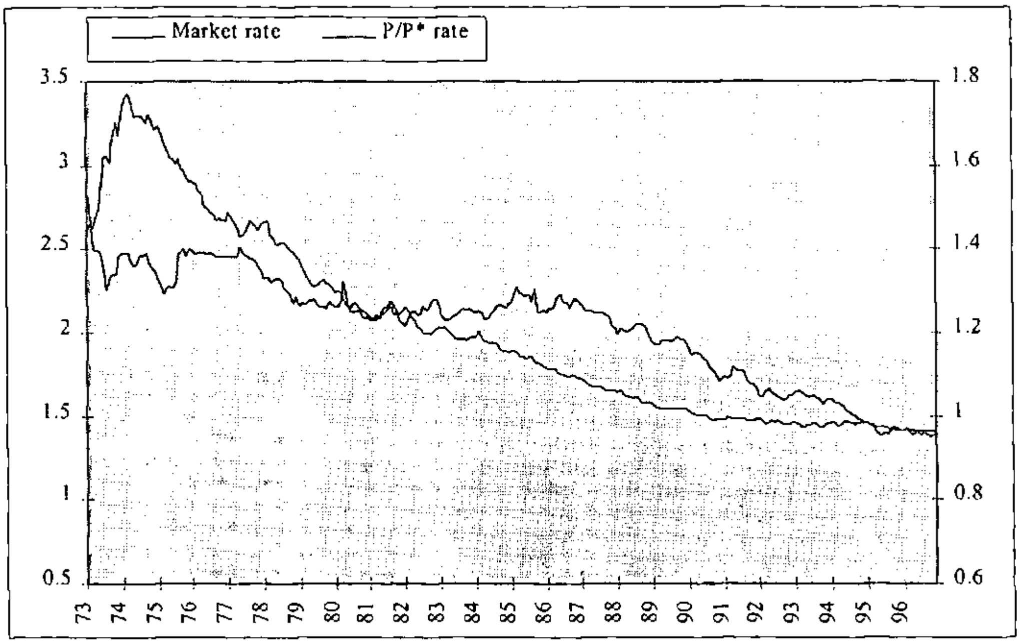
(c) Korea



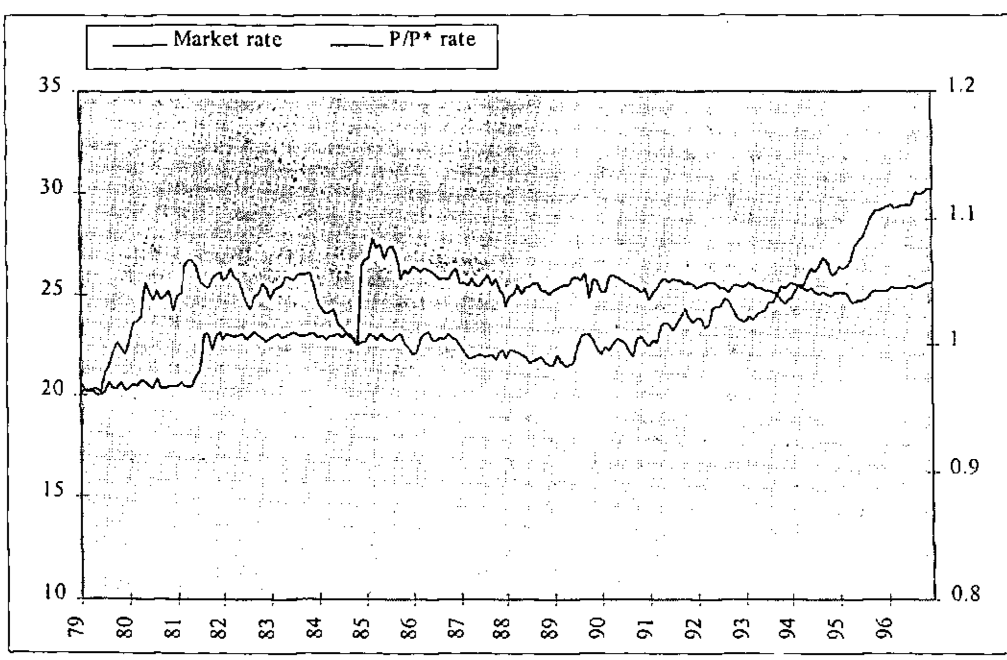
(d) Malaysia



(e) Philippines



(f) Singapore



(g) Thailand

In briefly, it is noticeable from all the plots that although the exchange rate is frequently far away from PPP it does have a tendency to go back to the PPP rate over the long run, which would suggest that there may exists comovement among the variables. However, the lengthy deviation of the two rates leaves us with a puzzle on how the simple PPP theory works reasonable well. How can we explain the sizeable and prolonged deviations of exchange rates from their purchasing power parity values? The long-run seems to be very long indeed. In addition, as having observed that, in a number of cases, there does not seem to be a clear tendency for the exchange rates to return to their PPP values over periods as long as twenty years. In the next section, the PPP hypothesis will be formally tested using some sophisticated econometric technique.

6.3 Unit root tests of real exchange rates

First, PPP is examined through the real exchange rate since the logarithm of the real exchange rate, q_t, can be defined as the deviation from PPP:

$$q_t = s_t - (p_t - p_t^*)$$

where s_t denotes the logarithm of the nominal exchange rate (domestic price of foreign currency) observed at time t, p_t and p_t* are the logarithms of the domestic and foreign price levels respectively.

It is clear that while q_t may be subject to considerable short-term deviation, a necessary condition for PPP to hold in the long run is that the real exchange rate q_t should be stationary over time, not driven by permanent shocks. In other words, since PPP can be taken as an equilibrium relationship and deviations from equilibrium are possible, the empirical implication is that if PPP is a strong driving force, the real exchange rate should have a tendency to move back to the equilibrium value indicated by PPP. If this is not the case, however, then the nominal exchange rate and the price differential will permanently tend to deviate from one another and the non-stationary real exchange rate is a result. This is the rationale for applying non-stationary tests to real exchange rate data as a means of testing for long-run PPP.

Thus, the time series property of the real exchange rate behaviour is examined here. The test is based on the ADF and the Phillips-Perron (PP) unit root tests.[7] The latter is usually said to be robust to serial correlation and various forms of time dependent heteroscedasticity. The null hypothesis implies that the tendency for the real exchange rate to return to some long-run equilibrium is very weak or non-existence.

The results of unit root test are presented in Table 6.2 for each of the countries. In the table, columns (1) and (3) are to test if the series is stationary around mean and columns (2) and (4) are to test if the series is stationary around a trend. The critical values for these two tests at 5% level are -2.88 and -3.43 respectively. The lag length for the ADF test is set at 12.[8] Looking at the results, it is not surprising that ADF test cannot reject the null hypothesis of unit root at any significant levels for all of the cases. The result from PP test is consistent with the conclusion from ADF test, which failures to reject the null of unit root

[7] The techniques for these two tests have been described in the chapter 5 and need no reiterate here.
[8] The justification for the lag length at 12 is as follows. First, in this chapter the monthly data are used, 12 lags is supposedly right and enough to remove serial correlation. Second, to further test if there exists serial correlation in the residual, the Ljung-Box Q-statistic is used and it is confirmed that there is no such problem. I have checked the lag length from 5 to 12, the results are not sensitive to the choice of lag length. That is, the series are non-stationary in levels but stationary in first differences with lags being from 5 to 12.

real exchange rate at any significant levels except the case of the Philippines. For the Philippines, the null hypothesis is rejected at 5% level. So our result overwhelmingly confirms that real exchange rate is non-stationary, contradicting PPP as a long-run equilibrium relationship during the floating period. It also coincides with the literature on univariate test for mean reversion in the major real exchange rates over the period since the 1970s. In this regard, this study has extended the previous research based on the industrialised countries, to the Asian economies with identical results.

Table 6.2 Unit root test of real exchange rates

	ADF test		PP test	
Country	τ_μ	τ_t	$Z(\alpha_{t*})$	$Z(t_{\alpha\sim})$
	(1)	(2)	(3)	(4)
Indonesia	-1.59	-0.92	-1.25	-1.27
Japan	-1.58	-2.35	-1.86	-2.32
Korea	-1.27	-2.00	-1.89	-3.13
Malaysia	-1.51	-1.28	-1.01	-2.94
Philippines	-1.72	-1.52	-3.34*	-3.01
Singapore	-1.44	-1.07	-1.91	-1.94
Thailand	-1.87	-1.27	-1.74	-1.28
5% critical value	-2.88	-3.43	-2.88	-3.43
1% critical value	-3.46	-3.99	-3.46	-3.99

The null hypothesis is that the series in question is I(1). τ_μ is the ADF t-ratio and τ_t is the ADF t-ratio with allowance for a time trend, while $Z(\alpha_{t*})$ and $Z(\alpha_{t\sim})$ are PP tests with and without a time trend respectively.
* Significant at 5% level
Lag is chosen at 12 for ADF test and lag truncation parameter for PP-test is set at 4.

However, as is well known, such tests possess low power. Hence previous studies attempting to find mean reversion in the post-Bretton Woods period, using univariate techniques, have usually failed, for instance, Meese and Rogoff (1988), and Mark (1990). The low power of such unit root tests may be due to the imposition of inappropriate common factor restrictions implicit in the model specifications (Kremers, *et al*, 1992). In estimating an ADF or PP test on the real exchange rate, one forces the short-term dynamics for the exchange rate and both price levels to be the same. In principle, there is no reason to believe that this condition should hold. Since observed price series are imperfect proxies at best for the theoretical price variables, the usual symmetry and proportionality restrictions under PPP are not necessarily consistent with empirical data. In this aspect, the cointegration method can usually provide an appropriate way to reveal the critical relations among the variables, since these restrictions can be tested and not imposed in cointegration analysis. Therefore, the PPP test will be carried on by using the cointegration procedure in the next section.

6.4 Cointegration test of PPP

In the framework of cointegration test, the empirical specification of PPP is based on the following model allowing for free coefficients for the domestic and foreign price indices and a free intercept:

$$s_t = \beta_0 + \beta_1 \; p_t + \beta_2 \; p_t^* + u_t \tag{6.1}$$

As it is already mentioned in previous chapters, under cointegration test, PPP is verified if (1) three variables constitute the long-run relationship and (2) the symmetry and proportionality hypothesis hold. The Johansen cointegration approach is adopted to investigate the long-run property of the exchange rate and prices and their relationships, with and without restrictions on the PPP parameters.

6.4.1 The order of integration

As is mentioned already, the premise of cointegrated variables is that each series should be integrated at the same order. So, we begin our cointegration test by examining the order of integration of the natural logarithm of the bilateral exchange rate and price index for each of the countries in our sample, with the United States serving as the reference country. The Augmented Dickey Fuller (ADF) test is performed for this purpose. The following equations are presented for the purpose of explaining the parameters concerned:

$$\Delta x_t = \mu + (\alpha - 1)\, x_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta x_{t-i} + e_t \tag{6.2a}$$

$$\Delta x_t = \mu^* + \beta^* t + (\alpha^* - 1)\, x_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta x_{t-i} + \delta_t \tag{6.2b}$$

where the lag length k is chosen so as to ensure that the residuals are white noise. Equations (6.2a) and (6.2b) are to test whether the variable x_t is stationary or stationary around a trend, respectively. The null hypothesis in the ADF tests is that x_t is nonstationary or has a unit root. In terms of equations (6.2a) and (6.2b), this implies that estimates of α and α^* in the two equations are equal to one.

Table 6.3 ADF unit root tests for series in levels and first differences

Panel A Series in levels

	Nominal exchange rates		Price indices	
	τ_μ	τ_t	τ_μ	τ_t
Indonesia	-1.35	-1.13	-1.01	-3.28
Japan	-1.06	-3.15	-2.55	-2.97
Korea	-1.92	-2.00	-1.02	-3.60*
Malaysia	-1.36	-1.89	-0.72	-1.82
Philippines	-1.80	-1.45	-1.37	-2.12
Singapore	1.01	-1.03	-0.61	-1.62
Thailand	-2.41	-1.97	-0.04	-3.64
United States			-0.89	-3.34

Panel B Series in first differences

	Nominal exchange rates		Price indices	
	τ_μ	τ_t	τ_μ	τ_t
Indonesia	-6.05	-6.12	-6.32	-6.55
Japan	-7.11	-7.11	-3.54	-4.66
Korea	-3.72	-3.68	-4.02	-3.96
Malaysia	-8.44	-8.42	-4.32	-4.38
Philippines	-5.16	-5.41	-2.71	-2.78
Singapore	-8.93	-9.06	-6.17	-5.99
Thailand	-6.37	-6.52	-4.04	-4.07
United States			-3.29	-4.75

The null hypothesis is that the series in question is I(1). τ_μ is the ADF t-ratio and τ_t is the ADF t-ratio with allowance for a time trend. Critical values for τ_μ at the 5% and 1 % levels are -2.88 and -3.46 respectively, and for τ_t at the 5% and 1 % are -3.43 and -3.99 respectively.

The number of lags is 12 for each series.

* denotes the 5% significant level.

The "*" is omitted from the Panel B since all statistics are significant at any levels.

Table 6.3 reports the estimated ADF tests with and without a linear trend for the data in levels (Panel A) and in first differences (Panel B). The lag length is set at 12 for all series and the Ljung-Box Q-statistic testing for serial correlation in residuals is used to confirm that all residuals are approximately white noise. Panel A indicates the results of the variables in levels, and it reveals that for all of the exchange rate series the null hypothesis of a unit root cannot be rejected at 5% significance level. Furthermore, Panel B presents the variables in the first differences and it is clear that the null hypothesis of a unit root is rejected for all of the currencies. Thus the exchange rates can be reasonably taken as being integrated of order one, i.e. I(1). To complete the tests, the ADF is also applied to the price indices. Again, the results in Panel A show that the price indices in levels are non-stationary. For the price indices in the first differences, the test rejects the unit root for all the price series overwhelmingly. Thus, all of the price indices can also be taken as I(1). In the whole, the results confirm that the series are integrated of order one; and further analysis on cointegration is, therefore, statistically profound.

6.4.2 Comovement of the nominal exchange rate and prices

Having established that each of the exchange rates and prices can reasonably be taken as I(1), we next examine whether the exchange rate and domestic and foreign prices are cointegrated. Before conducting the Johansen procedure, the order of the VAR, k, which often plays a crucial role in empirical studies, should be chosen. In selecting it, special care must be taken to ensure that it is high enough so that the disturbances are not serially correlated and that the remaining sample for estimation is large enough for the asymptotic theory to work reasonably well. Since it is well known that many cointegration tests formulated in dynamic frameworks are sensitive to the order of lag length (e.g. Stock and Watson, 1993), so in order to check the robustness of the results with respect to the lag length, Schwarz's BIC criteria is employed,[9] jointly with the Ljung-Box Q statistics to ensure the efficient use of information and a white noise residuals.

The results of the diagnostic tests for each country is shown in Table 6.4. Column 2 represents the order of the VAR to be chosen, based on the above criterion, and columns 3 to 5 are the Ljung-Box Q statistics for three residuals from each equations, that is, the nominal exchange rate, domestics and foreign prices. The Ljung-Box Q-statistic is to test for the joint hypothesis that all of the autocorrelation coefficients of residuals up to 8 lags are simultaneously equal to zero. The test is approximately distributed as the chi-square distribution with 8 degree of freedom, and the critical value for χ^2 with 8 degree of freedom at 5% significant level is 15.5. Looking at the Singapore case, for example, according the selecting procedure, the order of VAR is chosen as seven. With this lag length, the Ljung-Box Q statistics are 2.37, 6.81 and 8.73 for the residuals from nominal exchange rate, domestic CPI and US CPI respectively. The figures are all less than 15.5, the critical value at 5% significant level, indicating the rejection of serial correlation in residuals. Overall, the results confirm that all equations for seven countries have reached white noise residuals, which justify the choice of the order of VAR.

[9] Mills and Prasad (1992) show that Akaike's AIC criteria seems to overstate the dynamics in the system relative to the BIC criteria.

Table 6.4 Diagnostic tests

Country (1)	Lags (2)	Nominal exchange rate (3)	Domestic CPI (4)	US CPI (5)
Indonesia	8	2.82 (0.945)	3.32 (0.913)	3.27 (0.916)
Japan	5	3.42 (0.905)	2.29 (0.971)	2.47 (0.963)
Korea	5	8.14 (0.420)	3.14 (0.925)	7.42 (0.492)
Malaysia	6	2.32 (0.969)	12.59 (0.127)	7.52 (0.482)
Philippines	7	7.01 (0.536)	8.21 (0.413)	12.56 (0.128)
Singapore	7	2.37 (0.968)	6.81 (0.557)	8.73 (0.366)
Thailand	4	2.42 (0.966)	7.26 (0.509)	10.50 (0.232)

Notes: The numbers are Ljung-Box Q statistic which is to test for the joint hypothesis that all of the autocorrelation coefficients of residuals up to 8 lags are simultaneously equal to zero, which is approximately distributed as the chi-square distribution with 8 degree of freedom.
The numbers in the parentheses are the p-value.

Next, the results applying the Johansen procedure are reported in Table 6.5. Column 1 denotes the countries under consideration, Column 2 the number of lags used and Column 3 the number of cointegration vectors. The estimates of the maximum eigenvalue and trace statistics are reported in columns 4 and 5 respectively. The results indicate that in all the cases, the null hypothesis of no cointegration vector (r=0) is rejected at 1% level based on the both statistics, namely maximum eigenvalue (λ_{max}) and trace statistics. In the case of Korea, Malaysia, the Philippines and Thailand, the test statistic gives evidence of one unique cointegration vector; and for Japan and Singapore, the null hypothesis of one cointegration vector (r=1) is rejected based on both statistics, which implies that there may exist more than one cointegration vector. In the case of Indonesia, the maximum eigenvalue statistic accepts one cointegrating vector while the trace statistic suggests two cointegrating vectors. Based on the issue that the trace test appears to be more robust to non-normality of errors compared to the maximal eigenvalue, see Chueng and Lai (1993), there may exist two cointegrating vectors.

Our results are in contrast with those reported in previous study of East Asian currencies. For example, Baharumshah and Ariff (1997) fail to find cointegration relationship between nominal exchange rate and domestic and the US price levels indicated by CPI deflator, by using Johansen-Juselius method to the trivariate model. In all cases (Malaysia, Thailand, the Philippines and Singapore) but one (Indonesia), the null hypothesis of no cointegration cannot be rejected at 5% level, based on both the trace and the maximum eigenvalue statistics.

However, Chinn (1998) provides a positive results. Using Johansen procedure, he finds the evidence of cointegration relationship between exchange rate, domestic and foreign price levels based on CPI deflator, for the cases of Korea, Malaysia, the Philippines, Singapore and Thailand, but not for Indonesia, and the null hypothesis of unitary coefficients is rejected. So his results only confirm the existence of equilibrium relationship but not the strict PPP relation.

Table 6.5 Multivariate cointegration test of simple PPP

Country (1)	lags (2)	r (3)	λ_{max} (4)	Trace (5)
Indonesia		r=0	29.72**	50.58**
	8	r≤1	13.64	20.86**
		r≤2	7.22	7.22
Japan		r=0	70.82**	113.49**
	5	r≤1	37.91**	42.67**
		r≤2	4.76	4.76
Korea		r=0	43.07**	60.06**
	5	r≤1	9.92	16.99
		r≤2	7.07	7.07
Malaysia		r=0	28.73**	38.96**
	6	r≤1	7.58	10.23
		r≤2	2.65	2.65
Philippines		r=0	32.48**	48.79**
	7	r≤1	14.12	16.31
		r≤2	2.19	2.19
Singapore		r=0	27.14**	54.59**
	7	r≤1	22.23**	27.42**
		r≤2	5.19	5.19
Thailand		r=0	42.37**	56.87**
	4	r≤1	12.51	14.50
		r≤2	1.99	1.99
		r=0	22.04	34.87
Critical value at 5% level		r≤1	15.87	20.18
		r≤2	9.16	9.16

r denotes the number of cointegration vectors. The critical values of the maximum eigenvalue (λ_{max}) and the Trace statistics are taken from Osterwald-Lenum (1992).

** Significant at least 5% level.

The specification of the cointegrating VAR model is based on unrestricted intercepts, no trends.

Our result reveals that, for all of the countries, the exchange rate, domestic price and foreign prices seem to be cointegrated, suggesting that s_t, p_t and p_t* share a long equilibrium relationship. In other words, although three variables are non-stationary, the economic forces will prevent them move far apart without bound. This is consistent with the graphs shown at the beginning of the chapter. Nevertheless, the study of PPP is further subject to the restrictions on the parameters in the above cointegration vectors.

6.4.3 Tests of PPP vector

Our interest here is to test whether the PPP vector, which imposes restrictions on the cointegration vector such that $\beta = [1, -1, 1]$, is an element of the cointegration space. If the PPP vector is found in the cointegrating space, then the nominal exchange rate will move one-by-one with relative prices and the strong-form PPP is verified. This test is conducted by using the following likelihood ratio statistic (see Johansen-Juselius, 1990) where the null hypothesis is that the PPP vector is contained in the cointegrating space,

$$-2\ln Q = -T\sum_{i=1}^{r}\ln\{(1-\hat{\lambda}_i^{*})/(1-\hat{\lambda}_i)\} \tag{6.3}$$

where the $\hat{\lambda}_i^{*}$ and $\hat{\lambda}_i$ are the calculated eigenvalues from the restricted and unrestricted models, respectively; T is the sample size. This likelihood ratio statistic has an asymptotic χ^2 distribution, with degrees of freedom equal to the number of restrictions times the number of cointegration vectors. Since the PPP theory implies that β_1 and β_2 should be -1 and 1 respectively, therefore there are two restrictions on the cointegrating space. The results are reported in Table 6.6. The estimates of the cointegration vector β is normalised on the exchange rate, so the coefficient on the exchange rate is set to 1 and is omitted from the table; the parameters β_1 and β_2 are the coefficients on the domestic and foreign prices, respectively; and β_0 is the intercept term. Since the trace as well as the maximal eigenvalue statistic suggest that there are two cointegrating vectors for Indonesia, Japan and Singapore, the second cointegrating vector is also reported in the table. However, the existence of more than one cointegrating vector complicate interpretation of the results and it is difficult to offer a clear economic explanation in our case, it needs to chose one cointegrating vector for each country. The selection criterion is based on (a) the coefficients give the correct signs, and (b) the magnitude of coefficients is not far away from (1,-1,1). The selected cointegrating relation is printed in boldface.

Table 6.6 Test of symmetry and proportionality

Country (1)	β_1 (2)	β_2 (3)	β_0 (4)	LR (5)
Indonesia	**-1.36**	**3.13**	**-18.00**	14.87 (0.001)
	4.16	-13.32	34.85	
Japan	-19.19	8.72	43.37	
	-3.84	**3.88**	**-5.69**	60.68 (0.000)
Korea	-0.34	0.82	-9.07	21.39 (0.000)
Malaysia	0.98	-0.57	-3.03	25.02 (0.000)
Philippines	-1.91	4.58	-15.57	26.19 (0.000)
Singapore	**7.83**	**-3.53**	**-20.72**	17.56 (0.001)
	32.2	-25.26	-29.61	
Thailand	0.93	-1.01	-2.95	31.32 (0.000)

Note: β_1 and β_3 are the maximum likelihood estimates of the coefficients on the domestic and US price levels, respectively.
LR is the likelihood ratio testing for whether $\beta'=[1,-1,1]$ is contained in the cointegration space.
The number in the brace is the corresponding p-value.

Looking at the results, the estimated β matrices for the unrestricted models reveal that coefficient values differ substantially from the theoretical values of [1 -1 1]. This is very similar to what Cheung and Lai (1993) found in their study. The signs of cointegrating coefficients are as expected in terms of the definition of the real exchange rate, which is $q_t = s_t - p_t + p_t^*$, in four out of seven cases. Further, reviewing the corresponding LR statistics which are calculated from equation (6.3), we can see that the null hypothesis that the PPP-vector is contained in the cointegration space can be rejected for all of the cases.

The above tests present clear-cut results. For all of the cases under consideration, the exchange rate, domestic and foreign prices are cointegrated. That is, there exists long-run comovement between these series, which supports the weak-form PPP. However, the hypothesis of symmetry and proportionality is rejected in all cases, which means that the exchange rates do not move one by one with the relative prices of two countries. Therefore, the strong-form PPP does not appear to hold. The finding is consistent with most of the findings in the literature on the industrialised countries, for example, Pippenger (1993) and Kugler and Lenz (1993). These authors all use the Johansen-Juselius procedure and report the findings of cointegration combination but reject the hypothesis of symmetry and proportionality. The implications of these results are that the real exchange rate is non-stationary and the long-run PPP conditions are violated.

The fact that there exists a long-run relationship between the nominal exchange rate and price indices of two countries whereas the comovement of these three variables does not constitute one by one relationship may due to the following reasons: measurement error in the construction of price indices; tariff and non tariff barriers; changes in tastes, the deviations in productivity differentials, shifts in comparative advantage. One of the most common reasons for the failure of symmetry and proportionality to hold lies in the price index used. While in testing for PPP, it is important that the price indices are made up of similar commodities, using the same weights. This condition is, however, not an easy one even for the industrialised countries, as different countries give different weights to commodities based on their individual consumption and production patterns. It is possible that the price indices of the East Asian nations and the United States differ in somewhere, and such discrepancies are likely to be even larger.

Another assumption made when testing the PPP proportion is that there are no transaction costs and no trade restrictions between the countries. Although this is an analytically convenient assumption, it is not very realistic. Both transaction costs and trade barriers can cause a divergence in relative prices between countries. Regarding to the countries under study, this factor is likely important.

Regarding to our specific interest to East Asian countries, the rejection of PPP casts doubt on the ability of the flexible exchange rate system to insulate domestic economics from shocks originating abroad or on the desirability of even the "managed" or "dirty" float. The rejection of PPP implies that the real exchange rate is nonstationary. The results are in contrast with those reported by Phylaktis and Kassimatis (1994), regarding East Asian currencies. They test whether real exchange rate follows a random walk for eight Pacific Basin countries, using a first-order autoregressive process

$$q_{t+1} = c_0 + c_1 q_t + \varepsilon_{t+1}$$

estimated by generalised least squares (GLS). They find mean reversion in real exchange rates for most of the currencies such as Indonesian peso, Korean won, Malaysian ringgit and Philippine peso, Thai baht and Singapore dollar over the 1974-87 period. They explain their results as the greater degree of "openness" of the Pacific Basin countries compared to the major industrial countries. However, with different estimating methods, or probably different data period, our results do not support this view.

Apart from short-term deviations from PPP, there may exist some real variables violating the PPP conditions in the long-run and cause the permanent changes in real exchange rates. Since in testing for PPP, the overall price indices are used, which is made up of both traded and non-traded goods. There may also exist economic variables changing the relative price of traded to nontraded goods. Among these factors, an important factor may be the productivity differentials between two countries. It is well known that countries in the East Asian area had experienced the fast economic growth over the last decades. As a result, the Balassa-Samuelson hypothesis may exist in our example, which violates the validity of PPP and causes the permanent changes in the real exchange rate. This topic will be further investigated into in the next chapter.

6.4.4 Error correction models, exogeneity and disequilibrium adjustment

Although strong-form PPP does not seem to hold, but the long-run relationship is confirmed, which suggests that there may exist mechanism to adjust for the dis-equilibrium. Via error correction model, we can see how the exchange rate and price variables adjust over time to re-establish the equilibrium relationship.

Table 6.7 Test for exogeneity and disequilibrium adjustment

Country (1)	α-matrix (2)	α-estimated (3)	t-ratio (4)	p-value (5)
Indonesia	α_S	-0.0073	-2.73**	0.007
	α_P	-0.0027	-4.70**	0.000
	α_{P*}	-0.0016	-0.93	0.354
Japan	α_S	0.0036	1.83*	0.069
	α_P	0.0029	8.42**	0.000
	α_{P*}	0.0002	1.07	0.288
Korea	α_S	-0.0214	-2.56**	0.011
	α_P	-0.0108	-3.07**	0.002
	α_{P*}	-0.0087	-6.07**	0.000
Malaysia	α_S	-0.0397	-3.10**	0.002
	α_P	-0.0056	-1.36	0.175
	α_{P*}	-0.0084	-3.96**	0.000
Philippines	α_S	-0.0043	-0.33	0.742
	α_P	0.0088	2.54**	0.012
	α_{P*}	-0.0045	-4.47**	0.000
Singapore	α_S	0.0060	1.22	0.222
	α_P	-0.0095	-4.37**	0.000
	α_{P*}	-0.0027	-2.98**	0.003
Thailand	α_S	-0.0571	-2.61**	0.010
	α_P	-0.0144	-1.88*	0.062
	α_{P*}	-0.0181	-5.92**	0.000

α's are the estimated coefficients of error correction terms normalised consistent with β and the subscript of each α denotes the variable that adjusts to deviations from the long-run equilibrium, where s_t, p_t and p_t* represent the exchange rate, domestic and foreign prices respectively.
p-value is the marginal significant level.
** Significant at least at 5% level.
* Significant at 10 % level.

Specifically, consider the following vector error correction model (VECM):

$$\Delta x_t = \mu + \alpha \beta' x_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \, \Delta x_{t-j} + \varepsilon_t \qquad (6.4)$$

where x_t is a vector of variables in system. All terms in equation (6.4) are stationary. The coefficient α_i measures the response of x_{it} due to the past disequilibrium in levels (error correction term - the difference between the levels of the variables in the system). If α_i is not significantly different from zero, then the past disequilibrium has no effect on x_{it}. That is, x_{it} is weakly exogenous with respect to the long-run parameters, it drives the comovement of the variables in the cointegrated system. On the other hand, a significant α_j implies that variable x_{jt} endogenously reacts to the past disequilibrium and adjusts to restore the long-run relationship. Thus, by focusing on current changes in Δs_t, Δp_t and Δp_t^* to the previous period's disequilibrium, we can identify whether it is the goods market or foreign exchange market that is more responsive in offsetting the weak-form of PPP disequilibrium .

Turning to the estimated results shown in Table 6.7 where column 2 contains the components of the α matrix, column 3 the estimated α value, and columns 4 and 5 the t-ratio and related p-value respectively, corresponding to the estimated α_i value. The results show that the coefficients corresponding to the exchange rate (indicated by α_s), all are significantly different from zero except for the Philippines and Singapore. This demonstrates intuitively that the exchange rate adjusts to the disequilibrium implied by the error correction term in most cases. Further, inspecting the coefficients on domestic price (indicated by α_P), it can be seen that for most of the countries the coefficients are significant. Only in the case of Malaysia is the coefficients on domestic price not significant, suggesting it is weakly exogenous. Moreover, the coefficients on the US price (indicated by α_{p*}) are significant in five out of seven cases, which means the change in the US price is not exogenous. Overall, the results show that any deviation away from the equilibrium will lead to either exchange rate or domestic/US prices adjustment in the future that eventually eliminate the disequilibrium.

The results in Table 6.7 also provide information on the dynamic adjustment to the long-run equilibrium relationship embodied in the cointegration equation. For Indonesia and Japan, the long-run equilibrium adjustment is through the exchange rate and domestic price. For Korea and Thailand the adjustment towards the long-run equilibrium relationship takes place through exchange rates, domestic prices and US prices. However, for the Philippines and Singapore, the information provided by the error correction parameters seems to suggest that adjustment towards long-run equilibrium takes place only through price changes, from both the domestic and US price levels. The implication is that the exchange rate variable is "weakly exogenous" in these cases; i.e., the exchange rate is the initial receptor of an exogenous shock to the PPP relationship. The movement of the exchange rate away from its previous equilibrium level creates deviation from PPP, causing subsequent corrections through changes in the prices. For Malaysia, the domestic price reacts as the exogenous variable, and the disequilibrium adjustment takes place through exchange rate and US price. On the whole, the results imply that both exchange rate and domestic/US prices change to correct any deviations from long-run equilibrium.

Regarding the signs of α_s, they should be negative, as whenever there exists a disequilibrium, for example, if s_t is below the equilibrium, then in the next period, s_t should rise to eliminate this disequilibrium. Obviously, this negative disequilibrium could also be eliminated by positive changes in domestic price or the negative changes in the foreign price level. As a result, α_P should be positive and α_{P*} should be negative. It can be seen in Table 6.7 that most of the α_s and α_{P*} are correctly signed; however, most of the α_P appear to have the wrong sign.

The magnitude of α also provides the average speed of adjustment towards the estimated equilibrium state, i.e. a small coefficient indicates slow adjustment and large coefficient indicates rapid adjustment. In the case of Thailand, for example, the coefficient of α_s corresponding to s_t indicates that 5.71 percent of the disequilibrium is eliminated by exchange rate changes within one month. It is noteworthy that, by examining the estimated α values, the speed of adjustment coefficients corresponding to s_t (wherever it is significant) is larger than those for the other variables in the system. This is plausible from the theoretical point of view since, for the floating exchange rate period, the nominal exchange rate should be more responsive than prices to disequilibrium. However, the values of α are quite different from each country, suggesting that while comovement between the exchange rate and prices is present, the speed of adjustment to external shocks tends to vary across countries. On average, the speed of adjustment is very slow.

6.5 Conclusion

This chapter has tested the validity of PPP for seven East Asian countries *vis-à-vis* the US during the recent flexible exchange rate period. Our study extended the previous research on PPP to the emerging economies in the East Asian region. The unit root tests applying to the seven real exchange rates reveals that the real exchange rate is non-stationary, and hence rejects the PPP hypothesis. Further the cointegration test suggest that on the one hand, the nominal exchange rate and the price indices are cointegrated; and on the other hand, the PPP vector does not exist in the cointegration space. The sign of coefficients were correct only in four out of seven cases. Again, PPP seems do not hold.

It should, therefore, be admitted that the simple PPP theory, as formulated up to now, is incomplete. Further inquires into the reasons and factors behind this unexplained puzzle regarding the departure of PPP are necessary and demanding. Therefore, in the following chapters, the emphasis is to investigate empirically the sources which might violate the PPP and cause the non-stationarity of real exchange rates.

Chapter 7

Determinants of Equilibrium Real Exchange Rates

• Introduction

Up to this point, we have only focused on the simple purchasing power parity (PPP), that is the nominal exchange rate adjusted for the relative prices between two nations. However, as noted in the previous chapter, empirical test of PPP has not been successful in interpreting the movements of real exchange rates. Although the comovement between the nominal exchange rate and domestic and foreign prices is confirmed by the cointegration tests, the coefficient restrictions are generally rejected. Statistical evidence indicates that the real exchange rates are likely to be non-stationary or to have a long memory. This persistence implies that fluctuations in real exchange rates are largely due to the long lasting effect of real disturbances. Consequently, this suggests that the long-run equilibrium real exchange rate must be treated as a function of a set of real factors, of which the domestic and foreign price ratio is just one. The key to resolving the failure of the strong-form PPP lies in understanding the forces that keep the nominal exchange rate away from PPP equilibrium. Undoubtedly any element of this is related to the rigidity of prices in the face of nominal shocks while the remainder reflects the impact of real disturbances.

This chapter, therefore, searches for the sources of the failure of PPP and attempts to investigate the trend movements of the real exchange rates. The organisation of the chapter is as follows. In section 7.1, after a very brief review of the effects of changes in the fundamentals on real exchange rates and the ways in which the real factors influence real exchange rates,[1] a model is set up which incorporates these factors, and then the sources and characteristics of the data are explained. Section 7.2 is devoted to empirical applications of tests. The conclusion is provided in section 7.3.

7.1 Model specification and the data

The real exchange rate is defined as the nominal exchange rate adjusted for the general or overall price differentials between two economies. Since general price indices include both tradable and non-tradable goods, any potential disturbances that can cause changes in the relative price of non-traded goods will, in theory, bias the validity of PPP, or cause permanent changes in the real exchange rate. In chapter 4, it has demonstrated the role of relative price of non-traded goods in the influence of trend movements in real exchange rate. The equation is repeated here for demonstration:

$$q_t = -\alpha(p_t^{NT} - p_t^{T}) + \alpha^*(p_t^{NT*} - p_t^{T*}) \quad (7.1a)$$

or

$$q_t = -\alpha\rho_t + \alpha^*\rho_t^* \quad (7.1b)$$

where q_t represents the real exchange rate, and gives the price of foreign goods in terms of domestic goods; α's denote the shares of nontraded goods in the economy; p_t^T is the price of tradable goods; p_t^{NT} denotes the price of non-traded goods; $\rho_t = p_t^{NT} - p_t^T$ is the relative price of non-traded goods; * denotes the foreign economy. All of the variables are in logarithms.

[1] In the following, we use fundamentals, real factors, real disturbances, and real disturbances interchangeably.

In terms of equation (7.1a), movements in $p_t^{NT} - p_t^T$ or $p_t^{NT*} - p_t^{T*}$ drive movements in the real exchange rate. Several variables may influence this equilibrium of relative prices and cause the permanent changes in real exchange rates. Among them, productivity differentials between countries have been received most of the attention in the literature, with other possibilities being government spending, the world real price of oil, changing preferences, terms of trade and other factors such as changes in tastes, factor endowments and technological innovations, etc.[2] Although, from a theoretical perspective, all of the above factors might have influences on the long-run real exchange rate movements, however, not all of the data are readily available, especially for developing countries. This has to be taken into consideration in model building, and in the empirical specification, four variables are considered. They are productivity differentials, domestic and foreign government spending, and the world real price of oil. These factors are the most commonly empirically tested variables, see Strauss (1999), Dibooglu (1996), Zhou (1995), Chinn (1997) and others. The following briefly illustrates their effects in influence the movements of real exchange rates.

Productivity growth

The Balassa-Samuelson effect relies on differential productivity growth between an economy's traded and nontraded sectors, favouring the traded goods sector. It causes the equilibrium real exchange rate to appreciate over time, both because the excess demand is created in the non-traded goods sector and because the traded balance surplus tends to increase as a result of differential productivity improvements. Thus, rapid economic growth

[2] The importance of these variables and the ways they affect real exchange rates have been described in details in chapter 4.

is accompanied by real exchange rate appreciation. This effect has been investigated by, among others, Hsieh (1982), Canzoneri, *et al* (1999) and Marston (1987) with positive results. Regarding to the countries considered here, Japan is often cited as the classic case of a country where faster growth of productivity in the traded vs. nontraded sector, relative to its trading partners, has been associated with a real appreciation of a currency. This effect is expected to be significant for other East Asian countries for the reasons that have been well explained in the previous chapters.

Domestic and foreign government spending

Changes in the composition of government spending between traded and non-traded goods can affect the long-run equilibrium real exchange rate in different ways, depending on whether government spending is on traded or non-traded products. In reality, it is plausible to assume that most of the government purchases are on services which are dominantly on non-traded goods. As a result, the shocks from changes in government spending may have the positive impact on real exchange rate, i.e. leading the real exchange rate appreciation. The impacts of foreign government spending on real exchange rates should have the opposite effect. This factor has been investigated by Koray and Chan (1991) and Yoshikawa (1990), and they support the view that changes in government spending affect the movements of real exchange rates.

World real price of oil

The real price of oil has been identified as a major source of shocks to the flexible price equilibrium value of the real exchange rate. Amano and Norden (1995, 1998) focus on the term of trade. A rise in the real price of oil will worsen the balance of trade position of a net oil-importing country and, therefore, call for a real depreciation of the currency of the country in order to improve its competitive position. On the other hand, Chaudhuri and Daniel (1998) focus on the effect of oil prices on a country's producer price indices. In particular, when the price of oil increases, the relative price of the output bundle of commodities of an oil producing country should rise, compared with that of non-oil producing countries. This creases an increase in the oil producer's real exchange rate. However, since the countries differ in importing/exporting oil, whether this factor is significant depends on country's specific condition. For example, for Japan and Indonesia, the former is heavily dependent on oil importing while the latter is oil exporting, the impacts of changes in oil price are expected to have different effects in the movement of these two rates, in other words, the rising of oil price will depreciate yen while appreciate rupiah. For other countries, the influence of oil price on the bilateral real exchange rate relies on the difference between the two relevant countries in their dependence of imported oil.

An operational version of the model can be expressed as:

$$q_t = const + \beta_1 prod_t + \beta_2 gs_t + \beta_3 gs_t^* + \beta_4 Poil_t + v_t \tag{7.2}$$

where $prod_t$ is a measure of productivity differentials in the traded goods sector between the home and foreign countries, gs_t and gs_t* represent domestic and the US government spending respectively, $Poil_t$ is the world real price of oil, β_is are corresponding coefficients, and v_t is the error term. If the cointegration relationship exists among these variables, then equation (7.2) represents a long-run equilibrium of the real exchange rate, a significant β_i

means that the real exchange rate is explained by this *ith* variable. A positive relative productivity shock in the tradable goods sector is expected to cause the real exchange rate to appreciate, so the signs of β_1 should be negative. If the government spending on non-tradables increases relatively faster than tradeables, then β_2 is expected to be negative and β_3 positive, respectively. The sign of β_4 depends on how the increase in the world real price of oil affects the tradable and non-tradable sectors.

For the variables that have not been defined in the previous chapters are productivity differential, domestic and foreign government spending and the world real price of oil. To explore the influence of productivity in traded goods sector, $prod_t$, two variables are used as proxy the productivity in tradeables, depending on the availability of the data in different countries. For Japan, Korea, Malaysia and Singapore, the difference in the manufacturing productivity index between the home and the foreign equivalent is used. For Indonesia, the Philippines and Thailand, the manufacturing series is not available, so the real GDP index between home and the foreign equivalent is used.

However, the limitation of the data should be addressed here. To test the Balassa-Samuelson effect, our study is constrained by the availability of data on sectoral (tradable and non-tradable) productivity. The theoretical issue emphasises the differentials of the productivity between tradables and non-tradables. The extent to which the relevant theories can be tested empirically depends on whether the available data on employment and capital stocks are adequate for constructing quantitative measures of labour productivity or total factor productivity in the tradables and non-tradables sectors. DeGregorio *et al.* (1994) and

Chinn and Johnston (1996) are examples of using total factor productivity. Most of the works on productivity and real exchange rates have employed labour productivity rather than the total factor productivity measure suggested by the theory, see Hsieh (1982), Marston (1987), and Canzoneri *et al.* (1999). Canzoneri *et al.* argue that use of labour productivity is favoured because it is less likely to be tainted by mis-estimates of the capital stock. Although it is still not clear if labour productivity is a good proxy for total factor productivity, none of such data are available for our cases. Nevertheless, the data used here, the choice of which is inspired by Dibooglu (1996), are sufficient to illustrate a number of relevant points about the long-run behaviour of exchange rates. As the Balassa-Samuelson argument is regarding relationship between productivity and the real exchange rate, successful economic development results in a currency appreciation with improvement in the standard of living. Since growth in income and improvement in living standards come almost from growth in productivity, the growth rate is linked with increase in productivity. In this regard, it is justifiable to use the growth rate to capture the Balassa-Samuelson phenomenon.

Regarding to government spending on non-tradeables it is also not readily available, therefore the general government spending is used as proxy,[3] and is measured as the ratio of nominal government spending to nominal GDP. Although it would be preferable to have real government spending but such data is absence. The world real oil price was obtained from the IMF average crude oil price deflated by the IMF consumer price index, as representative of the general movement in oil prices over the period.

[3] It is assumed that the shock of government spending is mostly on nontraded goods.

All the data are collected from International Financial Statistics (IFS) of the International Monetary Fund, and are expressed in logarithms. Same as in the previous chapter, the sample period varies for each country and depends on when they adopted a floating or managed floating exchange rate regime. However, instead of using the monthly data, in this chapter the quarterly data are used. This is because that for some countries, some data are only available on the annual basis, such as GDP and government spending. In order to provide an adequate number of degrees of freedom as well as the accuracy of the data, the quarterly data rather than the monthly or annual data are used. To interpolate the annual data to quarterly one, the procedure of Minimising Squared First Differences by Boot, Feibes and Lisman (1967) is used.[4] The criterion of this method is to minimise the sum of squares of the differences between the successive quarterly values, subject to the constraints that during each year the sum of the quarterly totals should equal the yearly total.

Here, special attention is given to the time series properties of the variables. Since the fundamentals are defined as variables that affect the real exchange rate in the long-run, they should have the same order of integration as the real exchange rate. If the real exchange rate is stationary, in the sense that it reverts to a particular mean, then the fundamental should be stationary too, and the standard econometric estimation procedures can be utilised. However, if the real exchange rate is non-stationary, then any stationary variable cannot be a fundamental. This is because any variable that stochastically drifts permanently away from its mean cannot be affected in the long-run by a variable that reverts to its mean; the effects remain only in the short-term.

[4] For further details see Appendix 4.

7.2 Empirical results

7.2.1 The order of cointegration

We start the empirical work by examining the time series properties of each variable. Since the Phillips-Perron (PP-test thereafter) test is robust in that it allows for fairly mild assumptions concerning the distribution of the error, this method is applied to the levels and first differences of the variables. The results of the PP-test for each countries are reported in Table 7.1, where column 1 denotes the variables under consideration; columns 2 and 3 are the variables in levels and first differences, where t_μ and t_τ indicate, respectively, that only a constant and constant plus a time trend are included in the model; and the last column gives the quick description on how the variables are constructed.[5] For t_μ, the critical values at 5% and 1% significant levels are -2.89 and -3.51 respectively; and for t_τ, the critical values at 5% and 1% significant levels are -3.45 and -4.04. Looking the Philippines case, for example, the last column shows that the data span the period from the beginning of 1979 to the end of 1996, and the productivity differentials is proxied by the GDP index. For the variables in levels, t-ratio indicates that a unit root in real exchange rate is rejected at 5% significant level without trend and cannot be rejected when a trend is included, which means that real exchange rate is nonstationary around a trend. For the productivity differentials, a unit root cannot be rejected with and without time trend, which suggests that this series is stationary; while for the government spending, a unit root hypothesis is rejected for the series around a constant but cannot be rejected when a time trend is added, which implies that this series is nonstationary around mean. For the variables in first differences, t-ratio

[5] See Appendix 1 for the details of the description of the variables.

rejects a unit root for each series, which suggests that the variables are first difference stationary.

Inspecting the rest of the results, it can be seen that, for the variables in levels, the figure is not negative enough to reject the null hypothesis of a unit root for most of the series, with the exception of government spending for Korea, Malaysia, Singapore, and Thailand. However, the PP-test overwhelmingly rejects the null hypothesis of a unit root in every series in first differences, indicating that the series in the first differences are stationary. As a whole, our results are broadly consistent with the variables being integrated of order one, i.e., they are I(1) series. For government spending, the evidence is less certain and it could be I(0) in the cases of Korea, Malaysia, Singapore and Thailand. Given the motivation in the theoretical section, this variable is included in what follows. Its relevance can also be checked by the t-statistic in the cointegrating vector parameters.

Table 7.1 Phillips-Perron unit root test

Variables (1)	level (2)		First difference (3)		Data definition (4)
	t_{μ}	t_{τ}	t_{μ}	t_{τ}	
Indonesia					**79Q1-96Q4**
q	-1.20	-1.18	-9.38	-9.54	
Prod	-0.41	-1.51	-5.67	-5.67	**GDP**
gs	-0.64	-2.55	-3.85	-3.85	
Japan					**73Q1-96Q4**
q	-1.92	-2.58	-8.49	-8.48	
Prod	-1.47	-1.37	-6.78	-6.80	**Industrial production**
gs	-1.12	-1.81	-4.96	-4.95	
Korea					**80Q1-96Q4**
q	-2.15	-3.16	-8.56	-8.61	
Prod	-1.75	-2.01	-11.77	-12.28	**Industrial production**
gs	-8.39**	-8.40**	-27.37	-29.16	
Malaysia					**73Q1-96Q4**
q	-1.03	-3.25	-9.49	-9.53	
Prod / ID	0.23	-2.96	-11.76	-11.83	**Industrial production**
gs	-9.74**	-10.02**	-29.54	-29.73	
Philippines					**79Q1-96Q4**
q	-3.25*	-2.74	-12.12	-12.90	
Prod	-5.49**	-6.04**	-22.18	-22.33	**GDP**
gs	-2.09	-4.07**	-15.49	-15.50	
Singapore					**79Q1-96Q4**
q	-0.66	-1.55	-9.50	-10.46	
Prod	-1.23	-3.04	-11.79	-11.78	**Industrial production**
gs	-5.60**	-6.31**	-17.11	-17.35	
Thailand					**79Q1-96Q4**
q	-1.64	-1.07	-8.06	-8.23	
Prod	0.7	-1.42	-6.13	-6.23	**GDP**
	0				
gs	-4.45**	-5.28**	-18.45	-18.46	
US					**73Q1-96Q4**
gs	-1.98	-1.55	-6.52	-6.69	
World real price of oil	-0.41	-3.27	-9.45	-9.73	**73Q1-96Q4**
5% critical value	-2.89	-3.45	-2.89	-3.45	
1% critical value	-3.51	-4.04.	-3.51	-4.04	

Notes: The numbers denotes PP t-ratio. t_{μ} and t_{τ} indicate, respectively, that only a constant and constant plus a time trend are included in the model. The variables listed in the first column are as defined in the text.
* denotes the significance at 5% level
** denotes the significance at 1% level
Lag truncation parameter for PP-test is set at 4.

7.2.2 Long-run equilibrium relationship

In this content a long-run relationship means cointegration among several variables. The Johansen-Juselius maximum likelihood cointegration technique (Johansen (1988, 1991) and Johansen-Juselius (1990)) is applied to test whether the real exchange rate, productivity differentials, domestic and foreign government spending and the world real price of oil are cointegrated. If the cointegration relationship is confirmed, then the real exchange rate and the variables that are considered to be fundamentals should not deviate far apart and will form an equilibrium as follows,

$$q_t = \beta' x_t + z_t \tag{7.3}$$

where q_t is the real exchange rate, x_t is the vector of the fundamentals, β is the vector of cointegrating coefficients, and z_t is the error term, which should be stationary. Thus q_t in equation (7.3) can be considered as the long-run equilibrium real exchange rate that is determined by the fundamentals at each time period t.

Before running the Johansen-Juselius procedure, the optimal lag length in the VAR system has to be chosen. Here, the procedure used is based on the Schwarz Criterion, jointly with the Ljung-Box Q-statistic, to ensure the efficient use of information and a white noise residual. The procedure is as follows. The first is to set up a VAR(k) system, where k is chosen based on the Schwarz Criterion. The second is to check the Q- statistic to ensure the residuals from the chosen VAR are white noise. If the residuals from any equations can not be proved to be white noise, then the order of the VAR is increased by one until serial correlation of the residuals is removed.

Table 7.2 Diagnostic Tests

Country (1)	k (2)	Equation (3)	Q(8) (4)
Indonesia	5	79Q1-96Q4	
		q	0.19 (0.415)
		prod	2.22 (0.974)
		gs	13.85 (0.086)
		gs*	7.12 (0.524)
		Poil	7.59 (0.475)
Japan	5	73Q1-96Q4	
		q	3.33 (0.912)
		prod	14.19 (0.077)
		gs	7.11 (0.525)
		gs*	5.19 (0.737)
		Poil	8.62 (0.375)
Korea	4	80Q1-96Q4	
		q	2.43 (0.965)
		prod	5.54 (0.699)
		gs	8.66 (0.371)
		gs*	8.04 (0.430)
		Poil	5.55 (0.697)
Malaysia	10	73Q1-96Q4	
		q	2.28 (0.971)
		prod	2.82 (0.945)
		gs	3.64 (0.888)
		gs*	9.36 (0.313)
		Poil	8.57 (0.380)
Philippines	6	79Q1-96Q4	
		q	9.95 (0.269)
		prod	5.56 (0.696)
		gs	4.08 (0.849)
		gs*	9.94 (0.269)
		Poil	9.35 (0.313)
Singapore	5	79Q1-96Q4	
		q	3.40 (0.907)
		prod	4.38 (0.821)
		gs	9.23 (0.323)
		gs*	7.70 (0.463)
		Poil	10.74 (0.217)
Thailand	6	79Q1-96Q4	
		q	4.70 (0.789)
		prod	11.22 (0.190)
		gs	8.94 (0.348)
		gs*	6.73 (0.566)
		Poil	5.08 (0.749)

Notes: Q is Ljung-Box statistics test for the joint hypothesis that all of the autocorrelation coefficients of residuals up to 8 lags are simultaneously equal to zero, which is approximately distributed as the chi-square distribution with 8 degree of freedom.
The numbers in the parentheses are the p-value.

Table 7.2 reports the diagnostic tests for every equation in the unrestricted VAR. Column 2 gives the lag length chosen for each country, column 3 displays each single equation and column 4 reports the Ljung-Box Q-statistics, which test serial correlation for residuals up to 8 lags. The Q- statistic is approximately distributed as χ^2 with 8 degree of freedom. The critical value of $\chi^2(8)$ at 5% significant level is 15.5. The results show that for the lag length chosen, all of the residuals have been proven to achieve the white noise. Looking at the case of Japan, for example, following the procedure described above, the VAR specification is set at 5, and with VAR(5) system, all of the Q-statistics are below the 5% significant level. In other words, the joint hypothesis that all of the autocorrelation coefficients of residuals up to 8 lags are simultaneously equal to zero cannot be rejected, which means the residuals can be taken as white noise. Without mis-specification problem, it is save to turn to the next step to test whether there exist long-run relationships between the real exchange rate and fundamentals.

The cointegration results are presented in Table 7.3. The maximal eigenvalue and the trace statistic, reported in column 3 and 4 respectively, are used to determine the number of cointegrating vectors. The null hypothesis of no cointegration ($r=0$) is rejected by either the maximal eigenvalue statistic or the trace statistic in all the cases except Korea. Moreover, the hypothesis that there is at most one cointegrating vector ($r\leq 1$) is rejected by the trace statistic in most of the cases. Looking at the Singapore case, for example, the maximal eigenvalue statistic indicates the rejection of no cointegration ($r=0$) at 5% significant level while trace statistic implies that there may exist three cointegrating vectors among the variables. For the Korean data, since the trace statistic rejects the hypothesis of no cointegration at a modest 10% significant level,[6] we consider that there exists one cointegrating vector and check whether the variables enter the cointegrating relationship later.

Since the estimated vector, β in equation (7.3), indicates the long-run relationship between the exchange rate and the fundamentals, it is important to find out whether each of the variable enters the cointegrating relationship significantly and what kind of relationship exists between real exchange rate and the fundamentals. Table 7.4 reports the estimated coefficients, together with the corresponding standard errors. Before proceeding to a discussion of the results, the following points are worth bearing in mind. First, the Johansen-Juselius test suggests the existence of more than one cointegrating vector in some cases. However, the interpretation of such relationships is not straightforward, so we need to select one cointegrating vector for each country that best reflects the relationship between the exchange rate and fundamentals. The selection is based on signs of the coefficients that mostly correspond to the theory.[7] Second, the estimated coefficients in the *ith* row have the form of β_1, $-\beta_2$, $-\beta_3$, $-\beta_4$, $-\beta_5$, constant. Thus, when interpreting the results, except for the first element, q_t, all elements have the opposite sign to those in the corresponding regression equation on the right hand side. For example, the first row gives the cointegrating vector parameters for Indonesia, representing the following long-run reduced form relationship,

$$q_t = -4.943prod_t - 2.283gs_t + 5.119gs_t^* - 0.678Poil_t + 20.321$$

which can be interpreted as the long-run equilibrium real exchange rate of rupiah.

[6] In the light of the Monte Carlo results presented by Cheung and Lai (1993), in small sample the cointegration tests based on the trace test appears to be more robust to skewness and excess kurtosis in the innovations as compared to the tests based on the maximum eigenvalue statistic.

[7] After the one cointegrating vector is selected, the cointegration vector is normalised with respect to the real exchange rate for all the cases.

Table 7.3 Johansen-Juselius cointegration results

Country (1)	Data (2)	r (3)	λmax (4)	Trace (5)
Indonesia	79Q1-96Q4	r=0	41.96**	132.10**
		r≤1	39.95**	90.14**
	VAR(5)	r≤2	28.21**	50.19**
		r≤3	15.33	21.98**
		r≤4	6.65	6.65
Japan	73Q1-96Q4	r=0	55.49**	116.13**
		r≤1	26.98*	60.64**
	,VAR(5)	r≤2	19.54	33.66*
		r≤3	7.76	14.12
		r≤4	6.35	6.35
Korea	80Q1-96Q4	r=0	25.88	74.54*
		r≤1	17.31	48.66
	VAR(4)	r≤2	14.88	31.35
		r≤3	10.22	16.47
		r≤4	6.25	6.25
Malaysia	73Q1-96Q4	r=0	103.91**	191.69**
		r≤1	47.98**	87.78**
	VAR(10)	r≤2	24.62**	39.80**
		r≤3	10.40	15.17
		r≤4	4.77	4.77
Philippines	79Q1-96Q4	r=0	50.49**	117.05***
		r≤1	30.67**	66.56***
	VAR(6)	r≤2	15.15	35.89**
		r≤3	11.61	20.74
		r≤4	9.13	9.13
Singapore	79Q1-96Q4	r=0	44.20**	103.09**
		r≤1	21.40	58.89**
	VAR(5)	r≤2	17.09	37.49**
		r≤3	12.02	20.40**
		r≤4	8.38	8.38
Thailand	79Q1-96Q4	r=0	43.81**	124.91**
		r≤1	32.69**	81.09**
	VAR(6)	r≤2	22.46**	48.40**
		r≤3	18.34**	25.95**
		r≤4	7.60	7.60

Notes: r denotes the number of cointegrating vectors. The critical values of the maximum eigenvalue (λ_{max}) and the Trace statistics are taken from Osterwald-Lenum (1992). The critical values at 5% are 3.76(r≤5), 15.41(r≤4), 29.68(r≤3), 47.21(r≤2), 68.52(r≤1) and 94.15(r≤0) for Trace test respectively, and 3.76(r≤5), 14.07(r≤4) and 20.97 (r≤3), 27.07(r≤2), 33.46(r≤1) and 39.37(r≤3) for λ_{max} test respectively.

** Significant at least at 5% level

* Significant at 10% level

Table 7.4 Estimated cointegrating vector parameters (β in Equation (7.3))

Country	k	q	prod	gs	gs*	Poil	const	LR
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Indonesia	5	1.000	4.943	2.283†	-5.119	0.678	-20.321	1.58
		(0.000)	(1.544)	(1.276)	(1.287)	(0.107)	(4.105)	(0.209)
Japan	5	1.000	2.372	0.679	-3.494	-0.153	-12.116	na
		(0.000)	(0.525)	(0.147)	(0.890)	(0.034)	(2.323)	
Korea	4	1.000	-1.461†	1.504†	4.942†	-5.777†	12.063	6.44
		(0.000)	(1.649)	(0.838)	(4.191)	(0.618)	(14.738)	(0.169)
Malaysia	10	1.000	1.795	-3.630	-1.921†	1.207	-14.677	0.628
		(0.000)	(0.794)	(1.813)	(2.171)	(0.488)	(6.579)	(0.428)
Philippines	6	1.000	3.677	0.257†	-4.806	-0.105	-16.219	1.27
		(0.000)	(0.878)	(0.288)	(1.556)	(0.050)	(4.117)	(0.260)
Singapore	5	1.000	1.863	0.363†	-2.026	0.341	-6.711	2.43
		(0.000)	(0.852)	(0.357)	(0.851)	(0.152)	(2.317)	(0.119)
Thailand	6	1.000	0.749	0.530	-0.823	0.252	-5.408	na
		(0.000)	(0.063)	(0.090)	(0.106)	(0.021)	(0.429)	

Note: The numbers in columns 3 to 8 in the parentheses are standard errors.
The last column is the LR test of restriction of variable(s), marked with †, being zero, which is approximately distributed as the chi square distribution. The number below is the p-value.

There are a number of noteworthy points in Table 7.4. First, the results appear to support the hypothesis that the real exchange rate movement is explained by a set of real factors, implying that the data are not favourable to a mean reverting real exchange rate. Put differently, the fundamentals affect the real exchange rate movements in the long-run. Factors such as the productivity, domestic and US government spending and the real price of oil may cause the systematic deviations from PPP in the countries in our sample. In the case of Japan and Thailand, all the variables enter the long-run equilibrium relationship (cointegration) significantly, but the domestic government spending variable does not enter the cointegrating vector significantly for Indonesia, the Philippines and Singapore. This is an interesting finding in line with the argument that for a small open economy a change of its own government spending may not have an impact on the real value of its currency. For Malaysia, the real exchange rate is explained by domestic government spending, productivity differentials and the world real price of oil, but not by US government spending, while for Korea, none of the variables enter the cointegrating vector significantly. The last column in Table 7.4 is a likelihood ratio test (LR test) for the variables marked with † having zero coefficients, which is the test of joint restriction on relevant variable(s), and is approximately distributed as χ^2 with the degree of freedom being equal to the number of restrictions. The results show that all the relevant restrictions are not rejected, and once again suggest that the Korean exchange rate movement is not explained by the fundamentals considered here, though it may be explained by some other missing variables.[8] One of the possibilities is that the Korean currency may be correlated with the current account surplus/deficit as it has been noticed that the Korean won persistently depreciated against the US dollar due to the current account deficit and appreciated when it ran a current account surplus. To which factors this currency is connected is an interesting topic for further research.

[8] Bahmani-Oskooee and Rhee (1996) use the Johansen-Juselius cointegration technique and quarterly data over the period 1979-1993 to test the productivity bias hypothesis between Korea and four of its major trading partners (Germany, Japan, the UK and the US). They report the evidence that in all four cases the deviation of PPP from the equilibrium exchange rate has a long-run relationship with the productivity ratio. The reason that why this factor is not significant in our case may probably due to the different construction of the data and inclusion of other variables.

Second, the results show that in most of the cases, the estimated coefficients are consistent with economic theory, with plausible signs. Because the countries under study had grown quite rapidly by international standards over a large portion of the sample period, the Balassa-Samuelson effect are expected to generate a positive coefficient. The results confirm this point. The coefficient of productivity differentials is positive in all cases, which means that a faster growth of productivity in the home country relative to the US will lead to an appreciation of domestic currency in real term. Also the sign of government spending is broadly as expected, positive wherever statistically significant, with exception for Malaysia.[9] So the increase of the government spending, which is assumed to be mostly on non-traded goods, is associated with an appreciation of the real exchange rate in the home country. On the other hand, the sign of US government spending is negative, so this has the opposite effect and its increase, consequently, leads to a depreciation of the home currency. The impacts of the world real price of oil differ across countries, depending on their degree of dependency on imported oil as well as the various degrees of exchange rate intervention. An interesting point is that the coefficient is negative for Indonesia and positive for Japan, which implies that a real oil price hike may cause a rupiah appreciation and a yen depreciation. This is consistent with theory, as Indonesia is an oil exporting country while Japan is dependent on oil imports.

Third, our results highlight the important role of productivity differentials in producing permanent changes in real exchange rates. In all the cases except Korea, the productivity differentials elasticity is the largest or second largest, therefore, has great

[9] For Malaysia, changes in the local government spending cause depreciation of the local currency. This is consistent with the government spending falling on tradable, rather than non-tradable, goods.

impact on real exchange rates. It is, in fact, the most important factor in determining an appreciation in domestic currencies.

The results are in somewhat similar to what reported by Chinn (1997)[10] where he uses a single equation error correction model suggested by Phillips and Loretan (1991). His results suggest that the real exchange rate is cointegrated with productivity differentials for Japan, Malaysia and the Philippines. Government spending docs not appear to be a determinant of real exchange rates in the region except for Japan. When oil price is included in the model, it significantly explains the changes of real exchange rate in Japan (oil import) and Indonesia (oil export) with different directions, i.e. the increases in oil prices appreciates the Indonesian rupiah and depreciates the Japanese yen, the results being coincidence with ours. What is more is that he also finds that effect of government spending in Malaysia is associated with the depreciation of the real exchange ratc, which is exactly the same as what we have found here that the Malaysia government spending mostly falls on tradables rather than non-tradables.

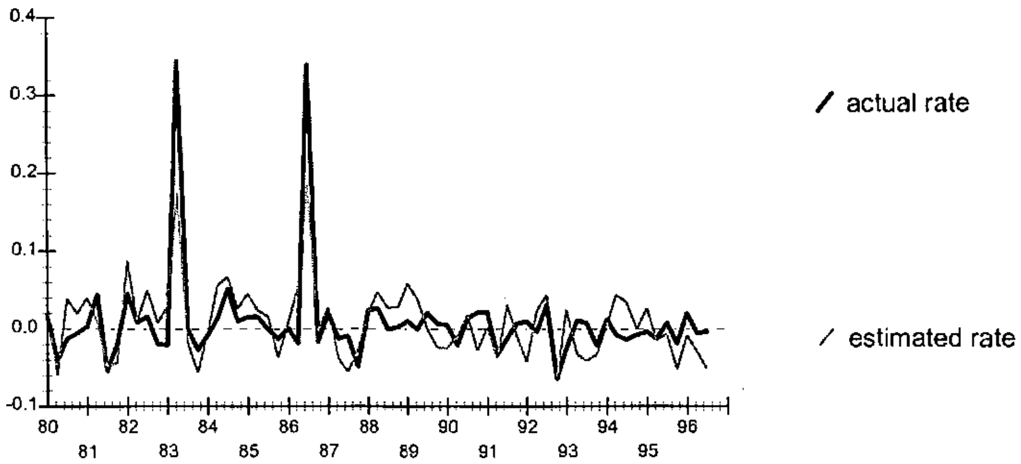
However, Isard and Symansky (1996) find a conflicting results regarding Balassa-Samuelson effect on APEC countries. They provide scatter plots for APEC members of average annual percentage changes in real exchange rates over the period 1973-92 versus average annual growth rates of GDP per capita and find weak correlation between the two variables, suggesting that per capita output growth by itself provides a poor explanation of long-run trends in real exchange rates. lto *et al* (1997) further explain the failure of the Balassa-Samuelson hypothesis to the real exchange rate behaviour of APEC countries as the

[10] In the study, the annual data are used, so there are at most 20 observations.

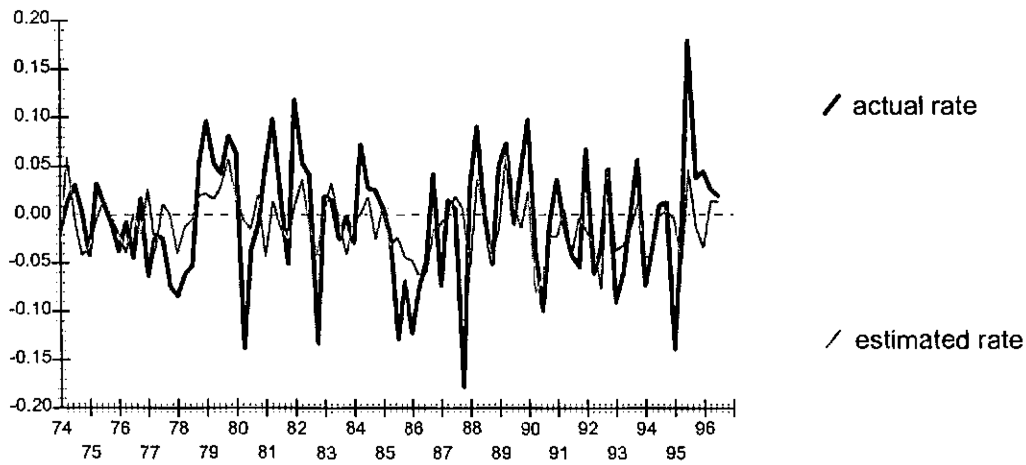
different stages of economic development these countries undertaking. Although they have provided visible and intuitive results which appear to be easy to understand, one of the shortcomings of such research is that it is not built on a solid econometric analytical ground and, consequently, is less convincing.

What do our results imply about the relationship between the actual and long-run equilibrium real exchange rates for these countries during the floating period? The answer to this question is given in Figure 7.1 where the estimated equilibrium rates are plotted along with the corresponding actual rates. It can be seen that, although the estimated rates frequently deviate from the actual rates, the fluctuations of the estimated equilibrium rates broadly coincide with the movements of the actual rates. Thus, the estimated equilibrium rates appear to explain the changes in the real exchange rate quite well. The implication is that fundamentals matter - not just in a statistical sense, as indicated by significant coefficients in Table 7.4, but also in the economic sense that the estimated time path of the real exchange rate is quite different from what would be predicted from a simple calculation based on PPP.

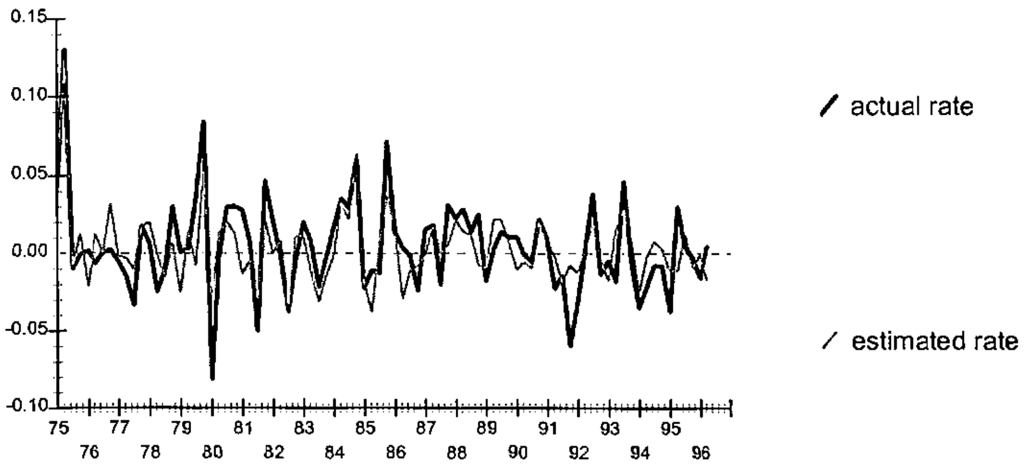
Figure 7.1 Actual and estimated equilibrium rates



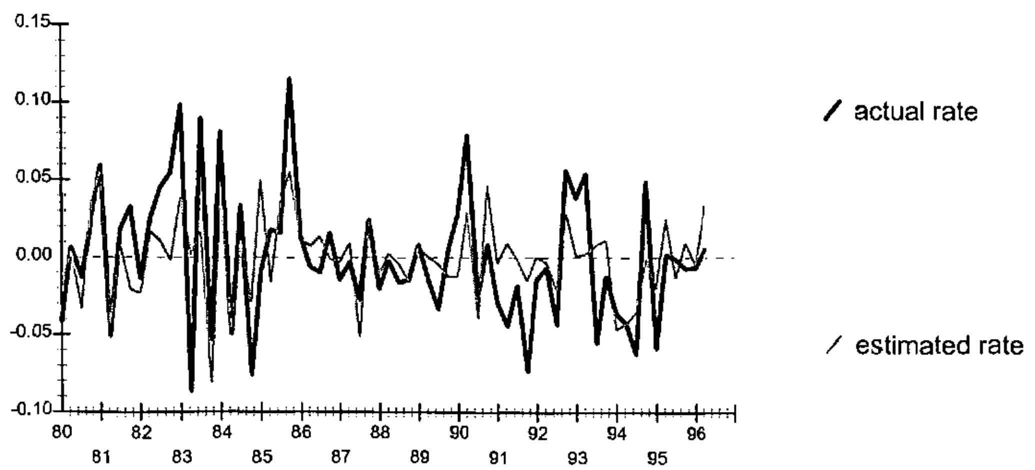
a: Indonesia



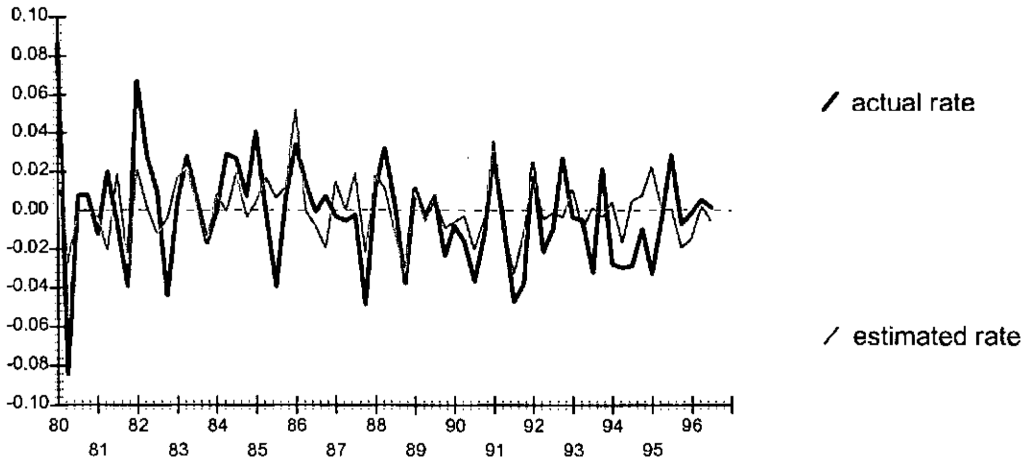
b: Japan



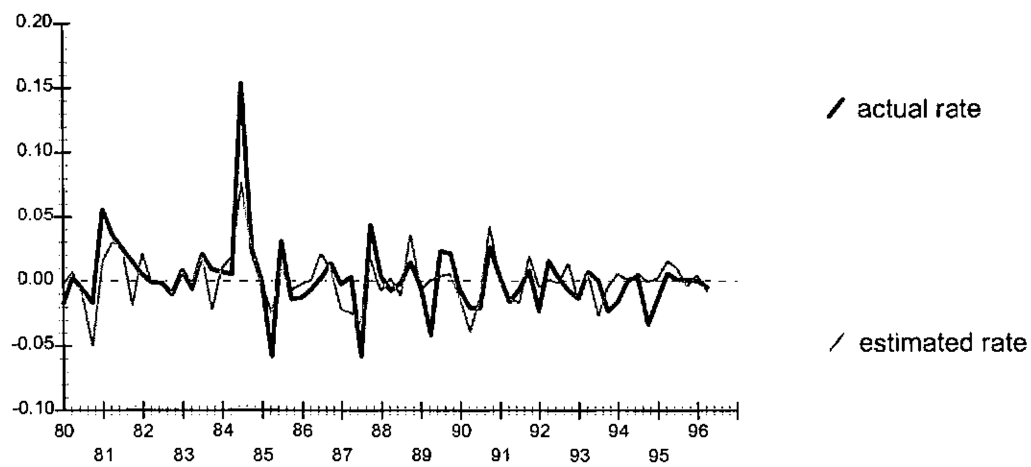
c: Malaysia



d: Philippines



e: Singapore



g: Thailand

7.2.3 Dynamic movements in the real exchange rates

The above long-run equilibrium real exchange rate under the framework of cointegration implies that the deviations from this value cannot be sustained permanently. In other words, such deviations must generate mechanisms that tend to move the actual real exchange rate in the direction of equilibrium. This section tests for the presence of such an error-correction mechanism by modelling empirically the behaviour of the actual real exchange rate in each countries.[11] The results are shown in Table 7.5 where the estimated α's (error correction coefficients) are reported together with the corresponding t-statistic. As is mentioned, the error correction term in the real exchange rate equation is the most important, which allows us to assess the stability of the equilibrium relationship presented in the last section and indicates the speed of adjustment to the long-run equilibrium. Two important points can be drawn from Table 7.5. First, the coefficient corresponding to the real exchange rate, α_q, is significant in four out of six cases (Indonesia, Japan, Singapore and Thailand). So the real exchange rate is the endogenous variable in the cointegrated system. Thus the lagged cointegration residual functions as a proxy for the forces driving the actual real exchange rate in the direction of their equilibrium value estimated in the last section and, second, the sign of the α_q is, as expected, negative in every cases. As a result, when there exists disequilibrium, with the real exchange rate above its equilibrium, for example, it will fall to restore the equilibrium relationship in the next period.

[11] The methodology involved in testing for the error correction representation has been described in Chapter 5.

Table 7.5 Exogeneity test

Countries (1)	α matrix (2)	Estimated α (3)	t-statistic (4)	χ^2 (5)
Indonesia	α_q	**-0.098***	**-2.85 (0.007)**	**4.34**
	α_{prod}	**-0.009**	**-1.51 (0.137)**	**(0.362)**
	α_{gs}	**0.0144**	**1.09 (0.282)**	
	α_{gs*}	**-0.009**	**-1.17 (0.250)**	
	α_{Poil}	**0.288***	**3.90 (0.000)**	
Japan	α_q	**-0.0974***	**-1.76 (0.083)**	**47.29**
	α_{prod}	**-0.0577***	**-3.79 (0.000)**	**(0.000)**
	α_{gs}	**0.0879***	**4.09 (0.000)**	
	α_{gs*}	**0.0245***	**2.16 (0.034)**	
	α_{Poil}	**-0.3079***	**-2.63 (0.010)**	
Malaysia	α_q	**-0.018**	**-1.43 (0.161)**	**74.82**
	α_{prod}	**0.016**	**0.90 (0.372)**	**(0.000)**
	α_{gs}	**0.236***	**5.42 (0.000)**	
	α_{gs*}	**0.014***	**3.40 (0.000)**	
	α_{Poil}	**0.037**	**0.69 (0.496)**	
Philippines	α_q	**-0.085**	**-1.55 (0.129)**	**32.85**
	α_{prod}	**0.050**	**1.31 (0.198)**	**(0.000)**
VAR(6)	α_{gs}	**-0.352**	**-2.12 (0.041)**	
	α_{gs*}	**0.030***	**1.96 (0.057)**	
	α_{Poil}	**0.628***	**4.47 (0.000)**	
Singapore	α_q	**-0.095***	**-1.95 (0.058)**	**23.58**
	α_{prod}	**-0.148***	**-2.94 (0.005)**	**(0.000)**
VAR(5)	α_{gs}	**-0.485**	**-1.58 (0.121)**	
	α_{gs*}	**0.026**	**0.37 (0.177)**	
	α_{Poil}	**0.780***	**3.27 (0.002)**	
Thailand	α_q	**-0.702***	**-3.32 (0.002)**	**11.45**
	α_{prod}	**0.056**	**0.82 (0.417)**	**(0.022)**
VAR(6)	α_{gs}	**-1.537***	**-2.85 (0.007)**	
	α_{gs*}	**0.188***	**1.99 (0.054)**	
	α_{Poil}	**-0.937**	**-0.88 (0.382)**	

Notes: The numbers in the column 3 are the estimated α's, column 4 is the t-statistic for the individual variable, together with the p-value in the parentheses. The column 5 is the χ^2 statistic for the joint restriction of the variables, that is α_{prod}, α_{gs}, α_{gs*} and α_{Poil} being zero. The reported values in the parentheses are the p-values.

* Indicates significant at least at 10% level.

The estimation of the error correction model yields highly plausible results. Kremers *et al* (1992) claim that the test for cointegration can be applied simply by evaluating the t-statistics on the error correction term. The above result confirms again that the real exchange rate is cointegrated with the fundamentals. The existence of the cointegration relationship between the real exchange rate and fundamentals implies the rejection of the PPP hypothesis. Real factors can cause permanent changes in the movements of real exchange rates. There is little tendency for the real exchange rate to be mean-reverting. Our result is in contrast with Phylaktis and Kassimatis (1994) who found that PPP held as a long-run equilibrium condition over the period 1974-87. One of the reasons might be that their data sample was too short to detect the impact of productivity differentials on the real exchange rate movements, since most of East Asian economies had been experiencing fast growth since the mid 1980s up to the end of 1996.

In Table 7.5 the α_is corresponding to the fundamentals are also reported and the tests of their weak exogeneity in the cointegrated system are further carried out. The results differ across countries. For example, in the case of Singapore, all α_is seem significant except α_{gs} and α_{gs^*}, which implies that all variables are endogenous in the cointegrating system, with domestic and US government spending weakly exogenous. For Japan, all of the variables appear to be endogenous. Productivity differentials are weakly exogenous in the cases of Indonesia, Malaysia, Philippine and Thailand; domestic government spending is weakly exogenous in Indonesia, the Philippines, and Singapore; US government spending is weakly exogenous in Indonesia and Singapore; and world real price of oil is exogenous in the cases of Malaysia, and Thailand. An interesting point is whether the productivity differentials, domestic and foreign government spending and the real price of oil are jointly weakly exogenous with respect to the long-run parameters, i.e. whether $\alpha_{prod} = \alpha_{gs} = \alpha_{gs*} = \alpha_{Poil} = 0$. The last column of Table 7.5 shows that the joint hypothesis is accepted for Indonesia, but rejected in all other cases.

Next, we establish the error correction model (ECM) for the six real exchange rates (ignoring Korea), incorporating the short-term dynamic movement and the long-run equilibrium adjustment of the real exchange rate and the fundamentals. The model is:

$$\Delta q_t = \alpha_q z_{t-1} + \sum_{i=1}^{k} \delta_i \Delta q_{t-i} + \sum_{i=1}^{k} \eta_i \Delta x_{t-i} + \varepsilon_t \qquad (7.4)$$

where z_{t-1} is the error correction term from equation (7.3), x_t is the fundamental vector which jointly determine the real exchange rate. Equation (7.4) shows that the real exchange rate in the short-term is affected by the error correction term, together with its past changes and past changes in fundamentals. Here only the real exchange rate equation in the whole system is reported, as it is our main concern and interest in this study. The model for the respective real exchange rate is as follows for each countries, with the insignificant variables excluded, and the figures below the equations are the t-ratio corresponding to the variable.

Indonesia:

$$\begin{aligned} \Delta q_t = &- \underset{(-2.85)}{0.098 z_{t-1}} - \underset{(-2.68)}{3.147 \Delta prod_{t-1}} - \underset{(-1.76)}{0.618 \Delta gs_{t-1}} - \underset{(-1.99)}{0.292 \Delta q_{t-2}} \end{aligned}$$

Japan:

$$\Delta q_t = -\underset{(-1.76)}{0.097z_{t-1}} - \underset{(-2.51)}{0.319\Delta q_{t-1}} + \underset{(1.71)}{0.231\Delta q_{t-3}} - \underset{(-1.86)}{0.84\Delta prod_{t-1}} + \underset{(1.85)}{0.865\Delta prod_{t-2}} + \underset{(2.27)}{0.856\Delta gs_{t-2}}$$

Malaysia:

$$\Delta q_t = -\underset{(-2.08)}{0.101\Delta gs_{t-1}} - \underset{(-1.84)}{0.302\Delta q_{t-2}} + \underset{(1.95)}{0.234\Delta prod_{t-4}} + \underset{(2.92)}{0.069\Delta poil_{t-7}}$$

Philippines:

$$\Delta q_t = \underset{(2.75)}{0.44\Delta q_{t-2}} - \underset{(-2.21)}{1.206\Delta gs^*_{t-2}} + \underset{(2.56)}{1.352\Delta gs^*_{t-4}} - \underset{(-2.18)}{0.259\Delta q_{t-5}}$$

Singapore:

$$\Delta q_t = -\underset{(-1.95)}{0.095z_{t-1}} - \underset{(-1.82)}{0.269\Delta q_{t-2}}$$

Thailand:

$$\Delta q_t = -\underset{(-3.32)}{0.702z_{t-1}} + \underset{(2.56)}{0.47\Delta q_{t-1}} + \underset{(1.89)}{0.373\Delta q_{t-2}} + \underset{(1.76)}{0.320\Delta q_{-3}} + \underset{(3.30)}{0.549\Delta q_{t-4}} - \underset{(-2.14)}{1.238\Delta prod_{t-1}} + \underset{(2.68)}{0.294\Delta gs_{t-1}} + \underset{(2.36)}{0.253\Delta gs_{t-2}} + \underset{(2.09)}{0.195\Delta gs_{t-3}} + \underset{(1.77)}{0.138\Delta gs_{t-4}} + \underset{(2.41)}{1.075\Delta gs^*_{t-1}} - \underset{(-1.81)}{0.890\Delta gs^*_{t-4}} + \underset{(2.24)}{0.114\Delta poil_{t-1}}$$

7.3 Conclusion

In this chapter the sources of fluctuations in the real exchange rate in seven East Asian economies have been investigated. The research methodology uses the framework of the Johansen-Juselius maximum likelihood cointegration technique, augmented by a number of real factors identified in the existing literature, to examine the cointegration relationship between the real exchange rate and fundamentals for these economies during the recent floating period. There are a number of noteworthy points emerged from this study. First, there exists the cointegration relationship between the real exchange rate and fundamentals, namely productivity differentials, domestic and foreign government spending, and world real price of oil, which suggests that these factors influence the real exchange rate in the long-run, implying that the real exchange rate is not mean-reverting. Second, the reduced form relationship between the real exchange rate and the fundamentals implies that the equilibrium real exchange rate appreciates with a rise in productivity differentials and domestic government spending, and depreciates with a rise in foreign government spending. The impact of an oil shock has different effects on real exchange rates across the countries. Third, the error correction term is significant and has the expected sign in most of the cases, implying that when a disequilibrium exists, the real exchange rate will react to restore the equilibrium.

Our results are consistent with the view that the fundamentals do play an important role in explaining the real exchange rate movements. Among these factors, the most important factor in our case might be the productivity differentials which support the Balassa-Samuelson hypothesis that if the relative price of non-traded goods changes, a bias will be introduced to PPP.

Chapter 8

Analysis of Fluctuations in Real Exchange Rates

• Introduction

In the previous chapters, it has been demonstrated that the empirical tests do not support the PPP hypothesis and that the real exchange rate is non-stationary for our sample during thc recent floating period. Further evidence suggests that there exists long-run comovement between the real exchange rate and the fundamentals, which implies that real shocks can induce permanent changes in the real exchange rate. Therefore, it is important now to investigate further, in addition to the relationships found in previous chapters, the patterns in real exchange rate changes following a specific shock to respective variables. For example, what would be the new equilibrium after a shock, how long would it take for the real exchange rate to reach the new equilibrium? This chapter extends the previous analysis moving from estimation and model fitting to the evaluation of possible future outcomes and performance of the real exchange rate. To provide detailed information on the relationships between the variables under investigation and the changing pattern or evolving path of each of the variables following a shock, this chapter uses the innovation accounting technique, i.e. impulse response and forecast error variance decomposition. Specifically, it traces out the time paths of the real exchange rates in response to various shocks to the variables contained in the VAR system. Moreover, it measures the relative contributions of each of the shocks to the forecast error variance of the real exchange rate. In a sense, the chapter extends the static results obtained in a given period to a dynamic analysis of the real exchange rate in the future,[1] and has more to offer when considering the policy implications and the likely effects of government intervention. Technically, two novel approaches, namely generalised impulse response analysis and persistent profile analysis,[2] will be used to investigate the time paths of the shocks to both individual variables and long-run cointegrating relationship. In what follows, the innovation accounting technique will be outlined in section 8.1, and followed by the discussion of the results of empirical applications in section 8.2. The final part, section 8.3, goes to the conclusion.

8.1 The structural VAR model

The comovement between the real exchange rate and the fundamentals observed in the previous chapter suggests that real factors might have a permanent influence on real exchange rates, that is, fluctuations in real exchange rates over the current floating rate period are mainly due to real shocks. Thus, having identified these real shocks, an interesting issue for exchange rate modelling is to determine how real exchange rates react to these shocks, i.e. the analysing the short-term dynamics, and identifying which factor is relatively more important than others.[3] To perform this, Lütkepohl and Reimers (1992) and Mellander *et al* (1992) show that innovation accounting can be used to obtain information concerning the interactions among the variables. They develop the asymptotic distribution

[1] This topic has not been well addressed in the literature with exception of Coakley and Fuertes (1997). In their paper, however, the short term dynamics of the PPP relationship is investigated rather than the equilibrium of real exchange rate.

[2] See Pesaran and Smith (1995) for an introduction to generalised impulse response functions and persistent profiles analysis.

[3] In the previous chapters, the unit root and cointegration techniques have been used. However, such approaches give only a limited use for studying short-term dynamics in a cointegrated system of variables. For example, unit root test gives little dynamic performance of variables except the half lives of shocks while cointegration approach provides a flexible dynamic structure of the variables through a VECM. The effects of various one-off shocks on the specific variable such as real exchange rate and on the long-run cointegration relationship can only be conducted via innovation accounting technique.

of impulse responses and forecast error variance components of a Gaussian VAR process with cointegrated variables. Considering a vector autoregression process of order k, VAR(k), for a system of n variables $y_t = (y_{1t}, \ldots y_{nt})'$ which is shown as follows,

$$y_t = a + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \ldots + \Phi_k y_{t-k} + v_t \qquad (8.1)$$

where Φ_i are n×n coefficient matrices; $a = (a_1, \ldots, a_n)'$ is n×1 vector of intercept terms allowing for the possibility of a non-zero mean $E(y_t)$; $v_t = (v_{1t}, \ldots, v_{nt})'$ is n-dimensional white noise or innovation process, that is, v_t has zero mean $E(v_t)=0$ and non-singular covariance matrix $\Sigma_v = E[v_t v_t']$ for all t; and finally, v_t and v_s are uncorrelated for $t \neq s$, $E[v_t v_s'] = 0$. The parameters a, Φ_1, Φ_2, ... Φ_k ean be estimated from the available data.

A stationary VAR(k) process (8.1) can be transformed to a vector moving average (MA) representation given below, which can be used to examine the interactions between the variables,

$$\begin{aligned} y_t &= \mu + v_t + A_1 v_{t-1} + \ldots \\ &= \mu + \sum_{i=0}^{\infty} A_i v_{t-i} \end{aligned} \qquad (8.2)$$

where $\mu = E[y_t] = (I - \Phi_1 - \cdots - \Phi_p)^{-1} v$ and the n×n coeffieicnt matrices, A_i, can be computed from Φ_i using the following recursive relations:

$$A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \ldots + \Phi_k A_{i-k}, \quad i = 1, 2, \cdots \qquad (8.3)$$

with $A_0 = I_n$ and $A_i = 0$, for $i < 0$. See Lütkepohl (1991) for a discussion of the relevant asymptotic in the representation of (8.2).

The MA coefficient matrices contain the impulse response of the system. More precisely, $a_{kj,i}$, the *kj*th element of A_i, is interpreted as the reaction of the *k*th variable to an impulse in variable j, i periods ago, provided that the effect is not contaminated by other shocks to the system. Since v_t are just the one-step ahead forecast errors of the VAR process the shocks considered here may be regarded as forecast errors.

However, one of the assumptions of this type of impulse response analysis is that a shock occurs in one variable at a time. Such an assumption may be reasonable if the shocks in different variables are independent, but if they are not, the error terms may consist of all the influences and variables that are not directly included in the set of y_t variables. On the other hand, correlation of the error terms may indicate that a shock in one variable is likely to be accompanied by a shock in another variable. In that case setting all other residuals to zero may provide a misleading picture of the actual dynamic relationships between the variables.[4]

For the above reasons, innovation accounting is often performed within a transformed VAR model where the white noise process has a diagonal covariance matrix, so that there is no instantaneous correlation among the components. The method is suggested by Sim (1980, 1981) and the Choleski decomposition is often used to orthogonalise the innovations.[5] The results of this approach are not, however, invariant to the ordering of the variables in the VAR. In a recent paper Koop *et al* (1996) have proposed the generalised impulse response analysis which was originally intended to deal with the problem of

[4] For the details of analysis see Lukepohl (1991).
[5] See Appendix 6 for the introduction of the Choleski decomposition.

impulse response analysis in the case of non-linear dynamic systems. Pesaran and Shin (1998) developed this approach for the multivariate time series models such as the VAR.[6] This approach does not have the above shortcoming. It does not require orthogonalization of shocks and is invariant to the ordering of the variables in the VAR. This is achieved by examining the shock in one of the variables, and integrating the effects of other shock using an assumed or historically observed distribution of the errors.

In this section we will use innovation accounting techniques to examine the relationships among economic variables, specifically to examine the dynamic effects of the real exchange rate in response to each of the disturbances, by performing variance decomposition and plotting the impulse response functions. Variance decomposition (VDC) measures the percentage contribution of each innovation to the h-step ahead forecast error variance of the real exchange rate. It thus provides a means of determining the relative importance of shocks in explaining variations in the real exchange rate. The impulse response function (IRF) shows the dynamic response of the real exchange rate (or long-run relationship) to a one standard deviation shock in one of the innovations of the system and, specifically, indicates intuitively the direction of the response to each of the shocks. It can also a rough analysis of how long it takes for the real exchange rate to go to the long-run level (or equilibrium is re-established) after being shocked.

[6] The elaborate of the technique can be seen in Appendix 6.

8.2 Empirical analysis

8.2.1 Variance decomposition analysis

We start with variance decomposition analysis. Since a cointegration relationship between the real exchange rate and fundamentals is confirmed by the Johansen-Juselius (1990) procedure in six out of seven cases,[7] the empirical work is based on the VAR model augmented with an error correction term (VECM) of the following form:

$$\Delta y_t = \alpha \ z_{t-1} + \sum_{i=1}^{k} \Phi_i \Delta y_{t-i} + v_t \tag{8.4}$$

where z_t is the error correction term representing the deviations from the 'long-run' equilibrium in period t-1. The y_t vector includes both the real exchange rate, q_t, and the fundamentals vector, x_t; v_t is the white noise; and k is the optimal lag length to ensure white noise residuals. The variables that appear in the x_t vector are: productivity differentials, domestic and foreign government spending, and the world real price of oil.[8]

In the above VECM system, each of the components of v_t is a white noise process with zero mean, constant variance and they are individually serially uncorrelated. However, the components of the vector v_t could very well be correlated with each other. Therefore, before proceeding to the test, the error variance matrix for each VAR should be checked. The estimated correlation matrix of residuals in the VECM system is shown in Table 8.1, which exhibits significant off-diagonal elements and thus indicates contemporaneous dependence between some variables.[9] Further, using the log-likelihood ratio statistic, a test

[7] See Chapter 7. It has indicated that for the case of Korea there is no cointegrating relationship between the real exchange rate and the fundamentals identified here. Therefore, the case is dropped for the further analysis.
[8] These factors have been identified in the previous chapter and are cointegrated with the real exchange rate.
[9] Here, the same rule is adopted as in the paper by Coakley and Fuertes (1997), that is, according to Enders (1995), if $|\rho_{12}| > 0.2$, the correlation is deemed to be significant, p.309.

of whether shocks in different equations are contemporaneously uncorrelated or not is also carried out and the results show that in all of the cases the null hypothesis cannot be rejected,[10] confirming significant off-diagonal elements and contemporaneous dependence between the variables. In such cases, GI (Generalised Impulse) analysis is favourable to traditional OI (Orthogonalized Impulse) analysis.

The generalised VDC is, therefore, applied to our analysis. Since we focus our attention on fluctuations in the real exchange rate, we only report the variance decomposition in the real exchange rate and analyse the relative importance of different real factors in the model in influencing real exchange rate movements. The results from VDC of the real exchange rate for five different forecasting horizons, that is 1, 4, 8, 12, and 24 quarters, are presented in Table 8.2.

It is interesting to note that the Indonesian rate is dominated by the real factors. About 79% of the one-step forecast error variance of the real exchange rate is accounted for by its own innovations and about 22% by the fundamentals. The proportions explained by the fundamentals increase over time dramatically and they explain about 85% of the variance after two years. In the long term, i.e. after a 24 quarters horizons, only 2.4% of the error variance is accounted for by the real exchange rate itself and the rest (97.6%) is explained by the fundamentals. For the Japanese yen, the fundamentals explain 6.2% variance for the first quarter horizon, and after 24 quarters, about half of the variance is accounted for by fundamentals.

[10] For the details of results see Appendix 5.

Table 8.1 System correlation matrix of the errors

		q	prod	gs	gs*	poil
Indonesia	q	1.00	-0.08	-0.19	-0.24	-0.09
5	prod		1.00	-0.12	-0.68	-0.03
	gs			1.00	-0.08	-0.18
	gs*				1.00	0.01
	poil					1.00
Japan	q	1.00	0.18	0.17	0.18	0.20
5	prod		1.00	0.14	0.42	-0.03
	gs			1.00	0.41	0.21
	gs*				1.00	-0.03
	poil					1.00
Malaysia	q	1.00	0.27	0.08	0.23	0.11
8	prod		1.00	0.04	-0.02	0.44
	gs			1.00	-0.11	-0.14
	gs*				1.00	0.33
	poil					1.00
Philippines	q	1.00	-0.12	-0.28	0.02	-0.07
6	prod		1.00	-0.21	0.02	0.28
	gs			1.00	-0.08	-0.04
	gs*				1.00	0.01
	poil					1.00
Singapore	q	1.00	-0.31	0.11	0.20	0.12
5	prod		1.00	-0.31	0.10	-0.19
	gs			1.00	0.05	-0.06
	gs*				1.00	-0.07
	poil					1.00
Thailand	q	1.00	-0.21	-0.06	-0.058	-0.244
5	prod		1.00	0.002	0.765	-0.033
	gs			1.00	-0.022	0.009
	gs*				1.00	0.115
	poil					1.00

Table 8.2 Variance decomposition for real exchange rates (%)

	Horizon	q	prod	gs	gs*	poil
Indonesia	1	79.29	3.56	21.08	3.78	0.46
5	4	38.67	8.08	20.10	7.59	29.03
	8	15.24	11.08	19.19	13.73	44.26
	12	7.68	9.44	19.62	18.94	43.94
	24	2.37	3.85	17.09	21.81	37.97
Japan	1	95.82	1.27	1.21	2.38	5.12
5	4	92.69	0.52	2.28	1.66	13.01
	8	86.69	0.93	2.72	1.99	19.03
	12	77.25	1.78	2.18	3.91	22.56
	24	52.77	2.73	1.19	11.39	27.51
Malaysia	1	95.20	3.62	1.05	2.31	1.27
8	4	94.36	5.90	1.21	1.37	2.41
	8	86.37	7.63	0.75	2.88	2.03
	12	81.73	9.10	0.55	3.90	2.23
	24	80.11	6.67	0.34	3.03	3.39
Philippines	1	95.55	0.88	10.71	3.69	1.68
6	4	90.09	1.50	8.62	3.56	6.73
	8	84.32	4.91	7.12	9.56	6.04
	12	84.10	7.22	7.00	9.64	5.14
	24	84.09	9.04	6.97	8.81	5.07
Singapore	1	96.87	11.70	0.63	5.19	0.81
5	4	91.17	18.04	0.62	11.71	1.19
	8	86.50	25.70	1.27	12.21	0.57
	12	82.44	31.53	2.30	12.15	0.36
	24	79.40	39.43	4.18	9.89	0.23
Thailand	1	86.82	5.91	0.47	1.16	9.61
5	4	70.41	2.93	2.01	5.56	18.77
	8	70.52	5.70	1.77	2.86	26.75
	12	70.99	7.36	1.30	2.00	30.37
	24	71.06	9.91	0.66	1.17	32.44

Estimated by generalised variance decomposition. The number is the proportion of the h-step forecast error variance of real exchange rate accounted for by the innovations in the real factors.

Note that due to the non-zero covariance between the original shocks, the sum of the decomposition is not necessary equal to one.

In contrast, the degree of forecast error variances of the real exchange rate explained by the fundamentals is much less for the other countries, and the movements of real exchange rates are mostly associated with its own historical innovations. For example, for Malaysia, the Philippines, Singapore and Thailand, around 87% - 97% of the forecast error variance is explained by the real exchange rate itself in the first quarter after the shock. Beyond 24 quarters, around 72% - 84% is accounted for by the real exchange rate itself and about 28% - 16% is explained by the fundamentals. In these cases, it suggests that the movements of the real exchange rate are mostly due to their own historical shocks although fundamentals account some of the changes.

The impacts of the real shocks vary by sources. Changes in the world real price of oil explain a substantial portion of the forecast error variance in real exchange rates in the cases of Indonesia, Japan and Thailand, from about 13-29% in one year to 28- 38% of the variance in 24 quarters. However, they do not explain much of the variances for Malaysia, the Philippines and Singapore. Productivity shocks seem to be more important for the Singapore dollar, accounting for 11.7% of the variance after one quarter and rising to 39% after 24 quarters. However, productivity shocks are less important for the Japanese yen,[11] which accounts for only about 2% of forecast error variance, and a little more important for the other economy, though less than 10%. Both domestic and US government spending shocks account for less than 10% of the variances, with the exception of Indonesia, which

[11] The result is in contrast with what has been found by Marston (1987). The reason might be the difference in time periods covered by the data sets used. In his study, the data cover the period 1973-83. During that time, the Japanese economy was experiencing faster growth compared with the US. Our data further extend the period to 1996. As is well known, during the 1990s, the Japanese economy has been declining. As a result, it is not a surprise that the Balassa-Samuelson effect hardly exists.

has 20% of the variance accounted for by domestic government spending, and Singapore, which has around 10% of the variance accounted for by the US domestic spending.

Using the proportion of forecast error variances of the real exchange rate that is accounted for by the real disturbances we can determine the relative importance of the shocks to each country. From Table 8.2, it can be seen easily that for the Indonesian rapiah, the change of real price of oil is the most important variable, and its movements have the greatest impact on the real exchange rate. The same factor is also the most important for the Japanese yen. The productivity differential variable seems to be an important factor for the Malaysian ringitt; and the US government spending for the Philippine peso. For the Singapore dollar, the productivity differential is the most important, and the US government spending is the next. In the case of the Thai baht, the real price of oil is the most important variable.

The results are, more or less, consistent with each country's specific situations. For example, both Japan and Thailand are short of energy supplies, so the changes of the price of oil have crucial impact on the movement of their real exchange rate. While the same factor is important for Indonesia, being an oil exporting country the impact of oil shock has reverse effect. Regarding to the changes in the differential of productivity growth, the factor may be expected to have greater impact on Singapore dollar, as that Singapore was experiencing the fastest growth rates of the sample. To some extent, the results also support the argument that for a small open economy with a big share parameter of traded goods, a change in its own government spending may not have much impact on the real value of its currency. This is certainly the case for Singapore.[12]

8.2.2 Impulse response analysis

The dynamic relationship among the variables can be best understood by examining the impulse response function. Here, the generalised impulse (GI) response analysis is used to examine the impact of the variable-specific shocks on both individual variables, specifically the real exchange rate, in the VAR model, and the long-run equilibrium relationship between the real exchange rate and the fundamentals. It also provides persistence profiles for the system wide shocks will also be examined. In a cointegrating VAR system, the impact of shocks on the individual variables is expected not to die out in the long-run, or equivalently, the variables will not return to their initial values if no further shocks occur. By contrast, the effects of shocks on the cointegrating relations will eventually die out and their time profiles can provide insights into the system's speed of convergence to the long-run equilibrium path.

(1) Response of real exchange rates to various shocks

Figure 8.1 displays the generalised impulse response functions for the levels of the real exchange rate for the six currencies. Each plot shows the dynamic response of the real exchange rate to various unitary shocks after zero period, one period, two periods etc., up to the limit of fifty periods for every country. A number of points can be noticed. First, each plot displays the long lasting effects of real shocks on the real exchange rate, that is, the response of the real exchange rate to a real shock is persistent and has a significant

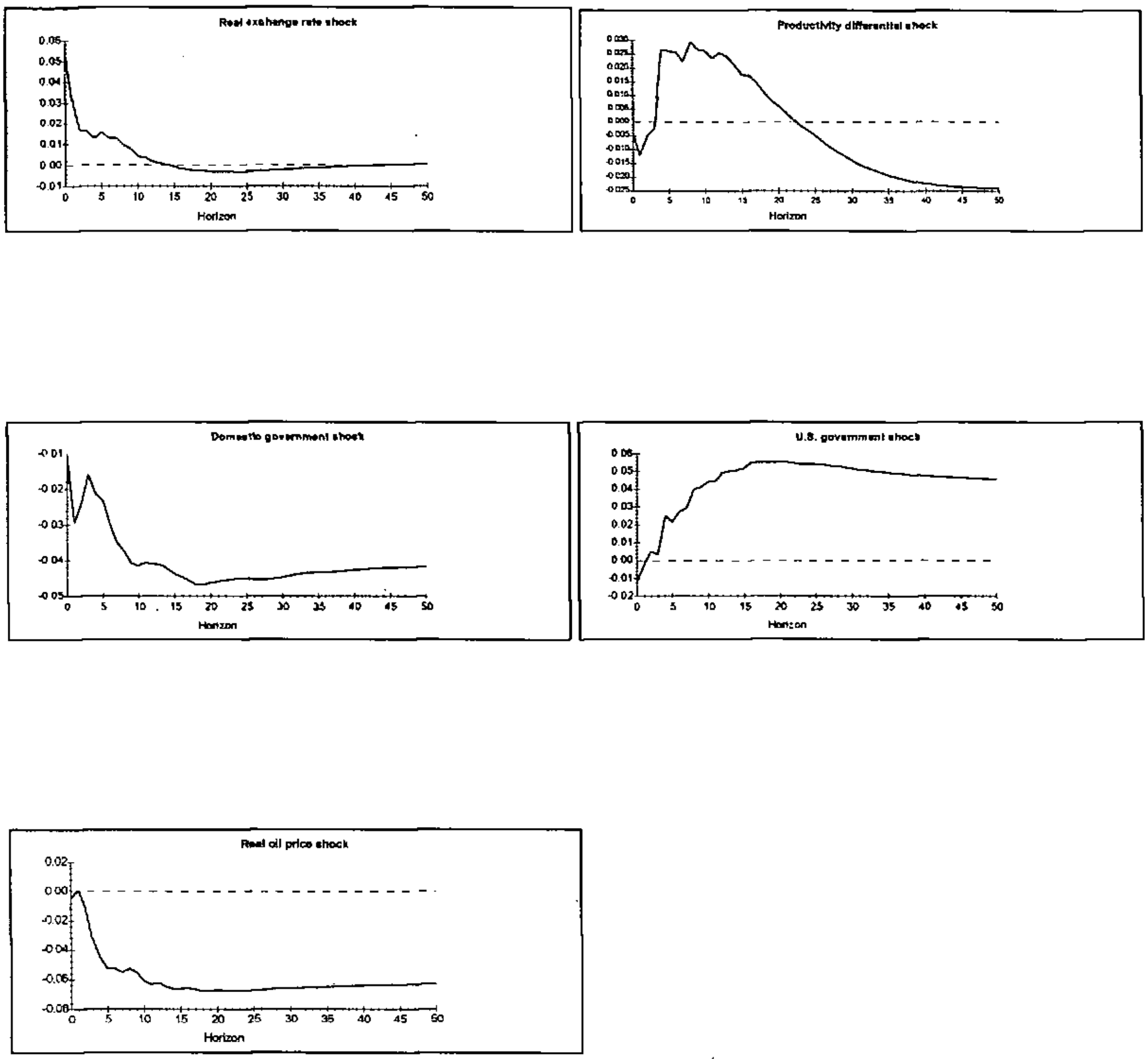
[12] Zhou (1995) provides the same evidence for the case of Finland.

permanent effect on the levels of the real exchange rate in each case. This is expected for non-stationary variables as mentioned already.

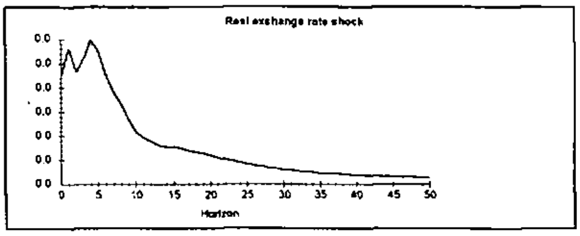
Second, the shapes of dynamic responses of real exchange rate on various shocks differ. In the above section on the variance decomposition analysis, we have sorted out the most important factors for each of the currencies. Here, we focus on these shocks and see how the real exchange rate responds to them. In the case of Indonesia, the oil price is the most important one. On impact the effect of the oil price shock is to appreciate the real exchange rate by 2%. This adverse effect continues to persist over the subsequent quarters. In the long-run, the effect of the oil price shock appreciates the Indonesian rapiah by 6% below its base-line value. In contrast, although the oil price is also an important shock to the Japanese yen, its effect is to depreciate the real exchange rate by 1.2% on impact. This effect persists for 13 quarters when the response of the real exchange rate approaches gradually the long-run value, which causes the Japanese yen to depreciate permanently around 4% above its base-line. This value reflects an ultimate real exchange rate response to the oil price shock. Both of these results are consistent with the theoretical argument, as Indonesia is an oil exporting country and Japan is more dependent on oil imports. A rise in the oil price would be expected to improve Indonesia's terms of trade, leading to a appreciation of the currency; while for Japan, the situation is reversed. With respect to Malaysia, the productivity shock seems important, but the time profile is not sensible. The plot shows that the productivity shock induces a real exchange rate depreciation by 0.68% on impact, reaching 1% after 15 quarters, which is odd since the expected effect is for an appreciation of the real value in the long-run.

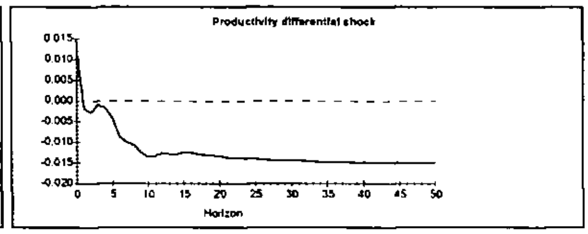
As for the Philippines, US government spending seems to be an important shock. Its effect, on impact, is to depreciate the real exchange rate around 0.2%, towards a long-run value of 0.3% deviation from its base-line. For Singapore, the productivity shock is important and it leads to an appreciation of the real exchange rate of 0.4% on impact, peaking at 0.9% after one quarter, then declining back to 0.4% appreciation permanently after 15 quarters. These reactions to shocks are as expected but for Thailand, the results are strange. As Thailand is dependent on imported oil, the effect of a rising oil price should be similar to that of Japan, i.e. associated with real exchange rate depreciation. However, the results show an appreciation of the real exchange rate. An explanation for this might be that, compared with the US, Thailand is less dependent on imported oil than US and so the impact effect of a rising of oil price is an appreciation of the currency. Figure 8.1 also shows the response of real exchange rate to the rest of shocks.

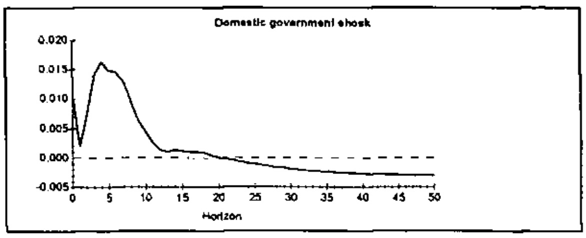
Figure 8.1 GI response(s) of real exchange rate to one S. E. shock

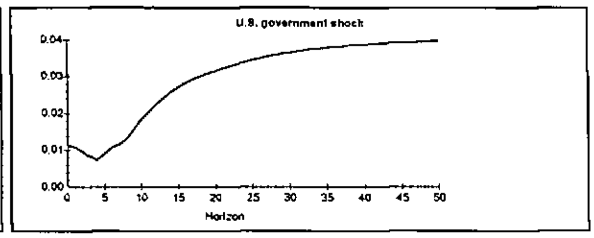


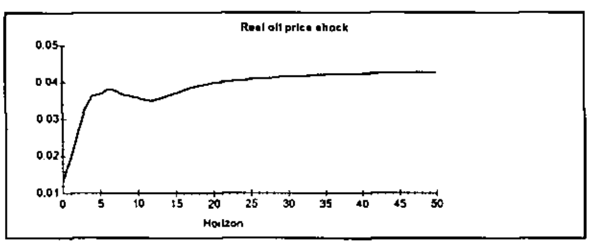
Indonesia


Real exchange rate shock
Horizon

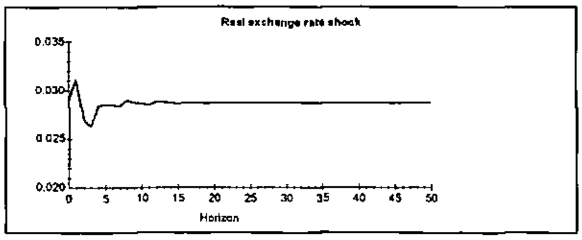

Productivity differential shock
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
Horizon

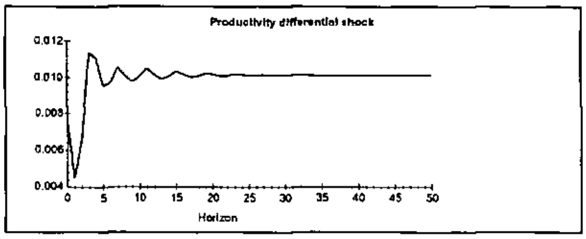

Domestic government shock
0.020
0.015
0.010
0.005
0.000
-0.005
Horizon

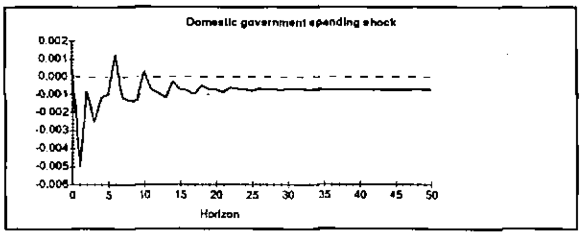

U.S. government shock
0.04
0.03
0.02
0.01
0.00
Horizon

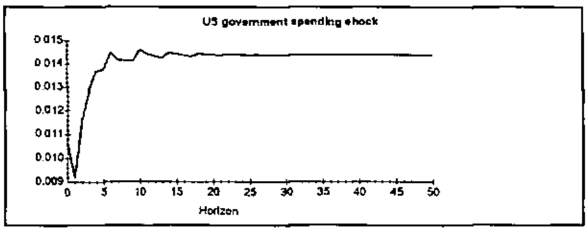

Real oil price shock
0.05
0.04
0.03
0.02
0.01
Horizon

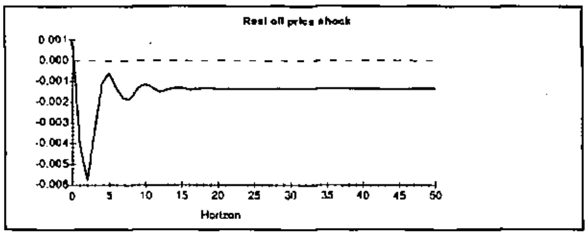
Japan


Real exchange rate shock
0.035
0.030
0.025
0.020
0
5
10
15
20
25
30
35
40
45
50
Horizon

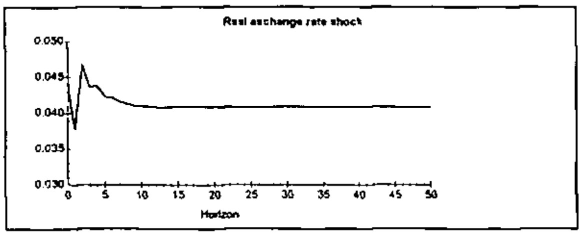

Productivity differential shock
0.012
0.010
0.008
0.006
0.004
0
5
10
15
20
25
30
35
40
45
50
Horizon

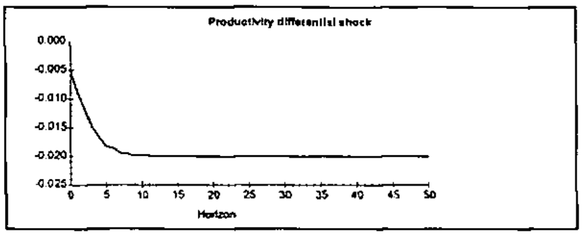

Domestic government spending shock
0.002
0.001
0.000
-0.001
-0.002
-0.003
-0.004
-0.005
-0.006
0
5
10
15
20
25
30
35
40
45
50
Horizon

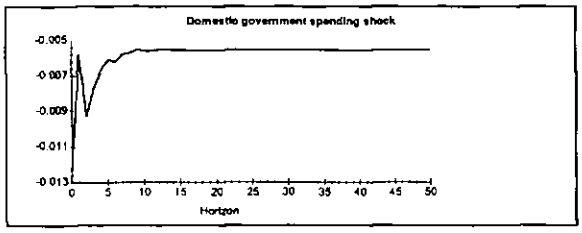

US government spending shock
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0
5
10
15
20
25
30
35
40
45
50
Horizon

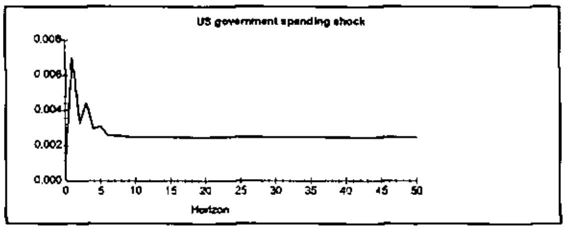

Real oil price shock
0.001
0.000
-0.001
-0.002
-0.003
-0.004
-0.005
-0.006
0
5
10
15
20
25
30
35
40
45
50
Horizon

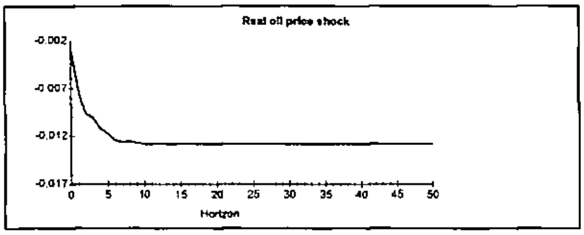
Malaysia



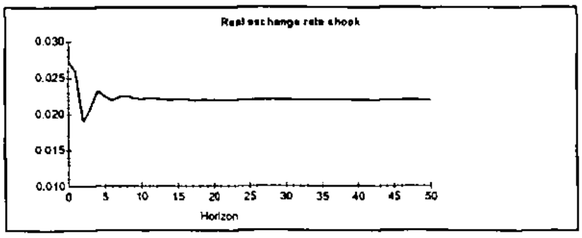


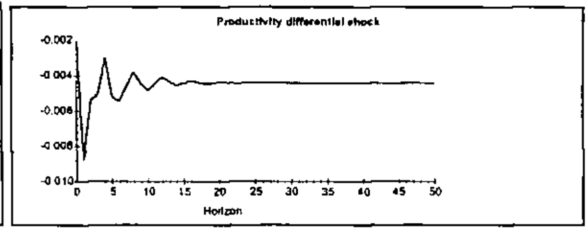


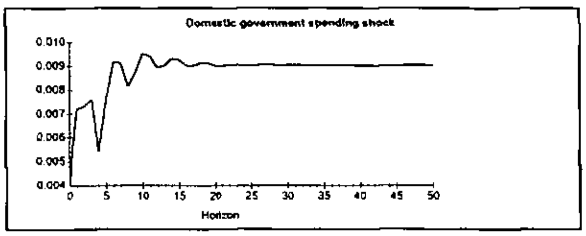


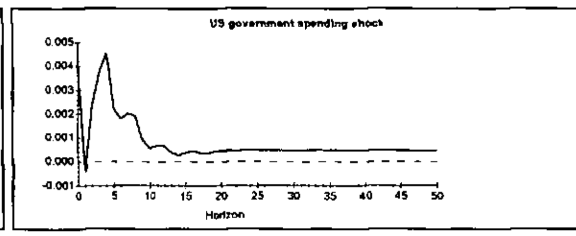


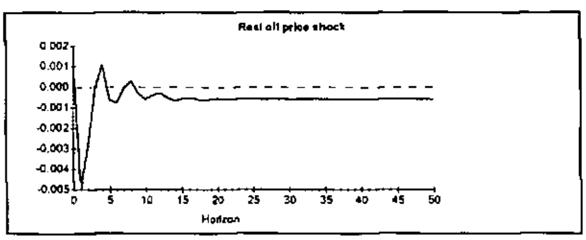
Philippines


Real exchange rate shock
Horizon

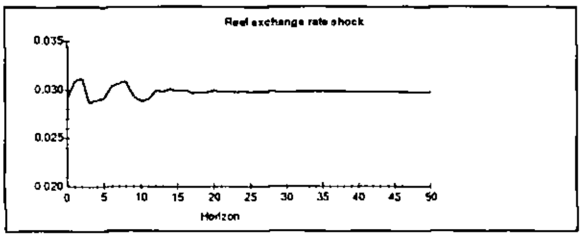

Productivity differential shock
Horizon

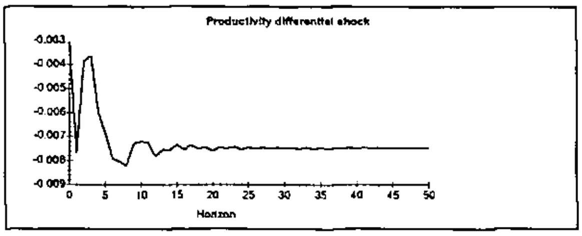

Domestic government spending shock
Horizon

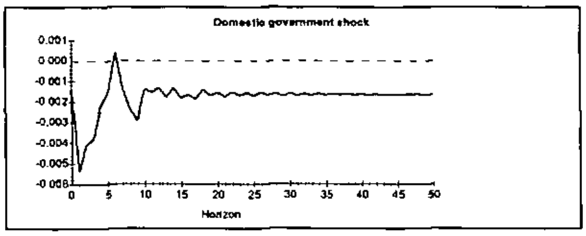

US government spending shock
Horizon

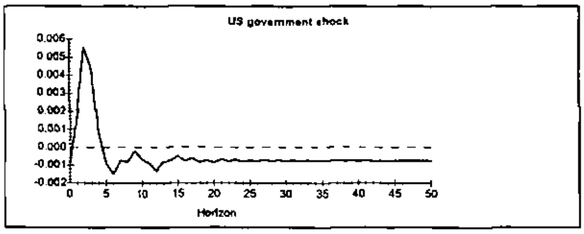

Real oil price shock
Horizon

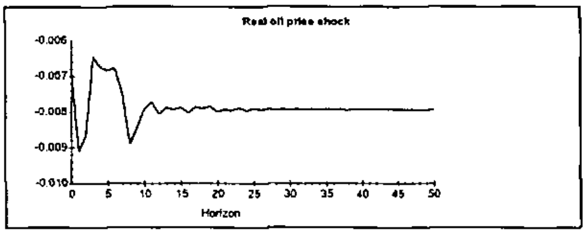
Singapore


Real exchange rate shock
Horizon


Productivity differential shock
Horizon


Domestic government shock
Horizon


US government shock
Horizon


Real oil price shock
Horizon

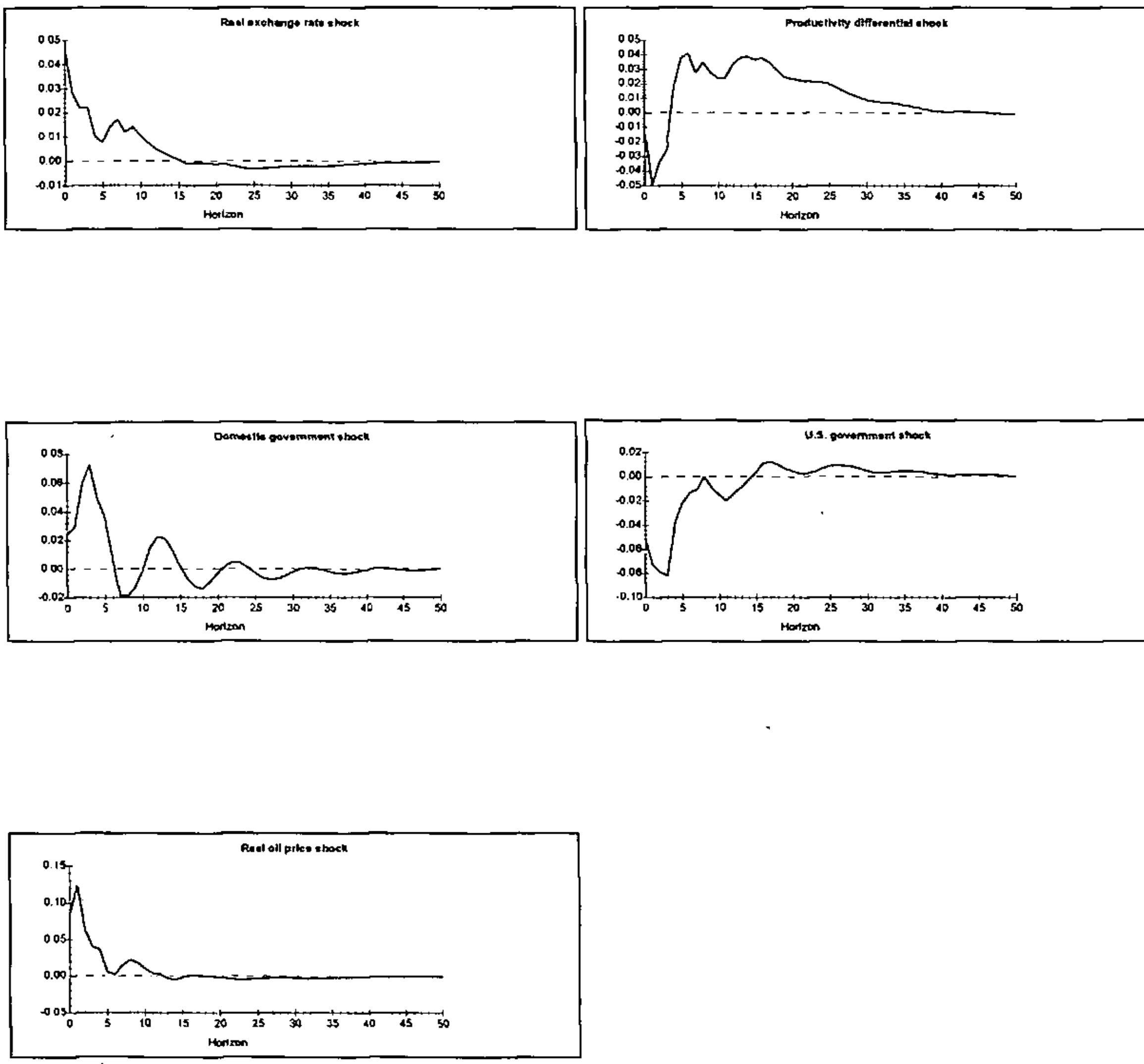
Thailand

(2) Response of long-run relationships to various shocks

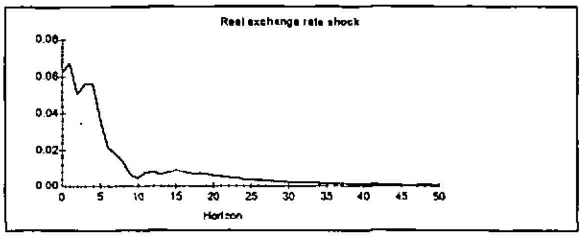
GI analysis applied to the long-run equilibrium relationship (cointegrating vector) indicates that the impact of one-off shocks is, as expected, transitory.[13] In fact, all of the variables reach their new equilibrium point when the transitory period has finished, so there is no further adjustment. Figure 8.2 plots the response of the long-run relationship to the various shocks. As can be seen, all long-run relations converge to zero after the effect of the shocks die away, although the time paths have different shapes for the different shocks. One interesting feature of this kind of experiment is that it gives a feeling of how long it takes the system to adjust back to the equilibrium after a real disturbance, or shock, occurs. The life of such shocks ranges from around 10 quarters to 40 quarters, that is between 2.5 to 10 years. As such, the transitory period is rather long for some cases. This is because transition will not be complete until all the variables in the system have settled down on their new equilibrium point, so it is equal to or greater than the period for any individual variable.

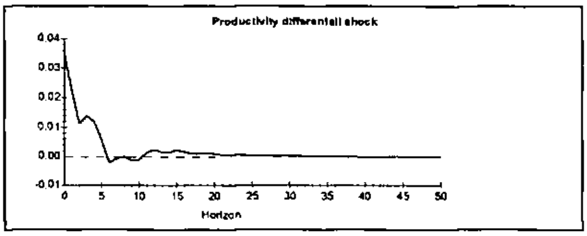
[13] As Pesaran and Shin (1996) demonstrate for the case of the UK.

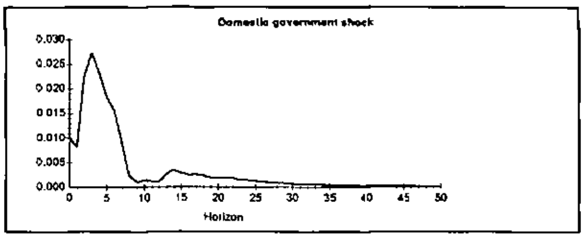
Figure 8.2 GI response(s) of long-run relation to one S.E. shock

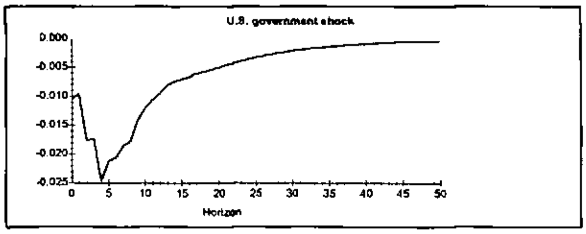


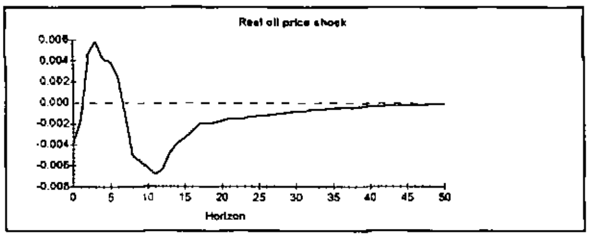
Indonesia


Real exchange rate shock
Horizon

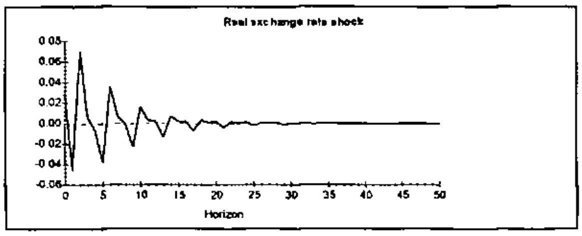

Productivity differentiall shock
Horizon

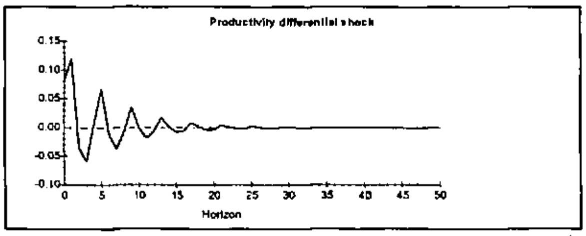

Domestic government shock
Horizon

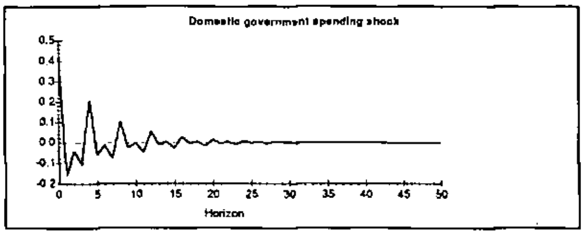

U.S. government shock
Horizon

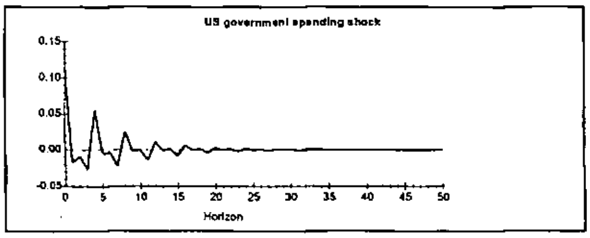

Real oil price shock
Horizon

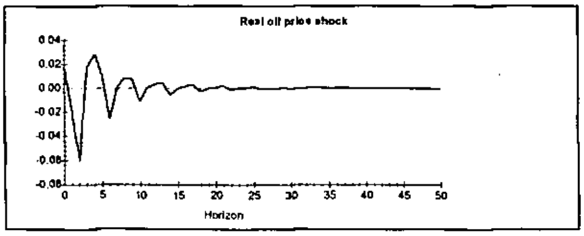
Japan


Real exchange rate shock
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
0 5 10 15 20 25 30 35 40 45 50
Horizon

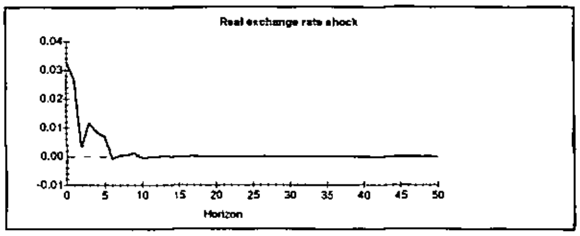

Productivity differential shock
0.15
0.10
0.05
0.00
-0.05
-0.10
0 5 10 15 20 25 30 35 40 45 50
Horizon

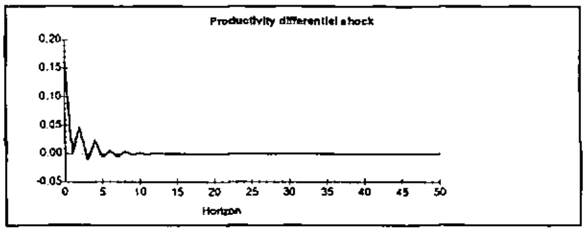

Domestic government spending shock
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
0 5 10 15 20 25 30 35 40 45 50
Horizon

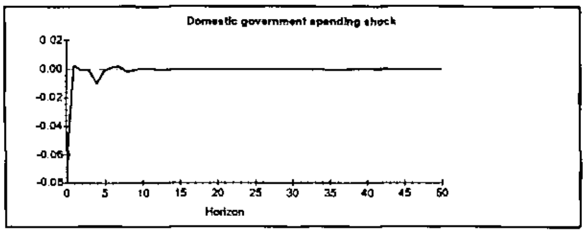

US government spending shock
0.15
0.10
0.05
0.00
-0.05
0 5 10 15 20 25 30 35 40 45 50
Horizon

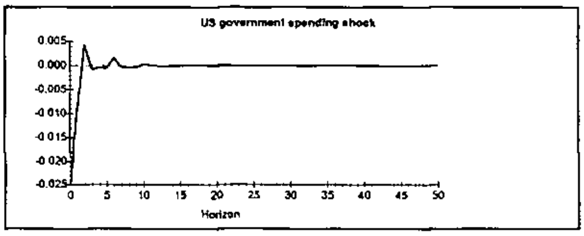

Real oil price shock
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
0 5 10 15 20 25 30 35 40 45 50
Horizon

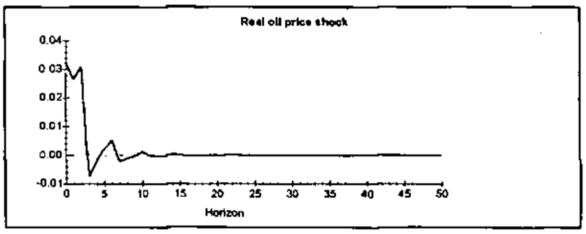
Malaysia



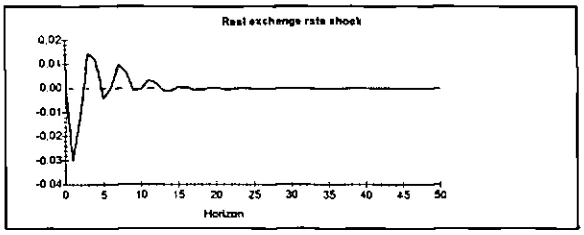


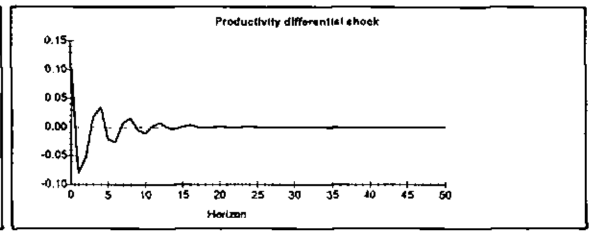


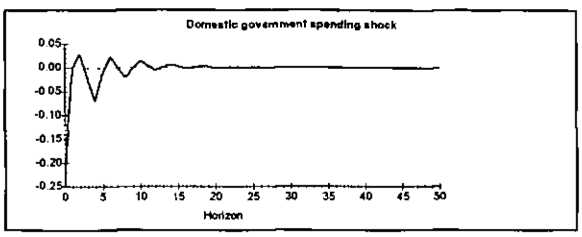


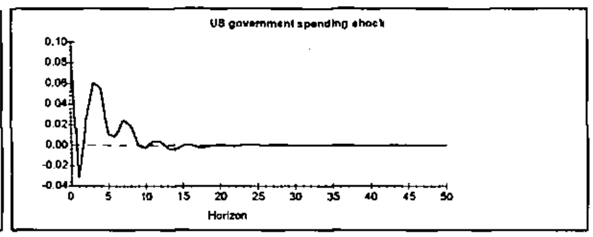


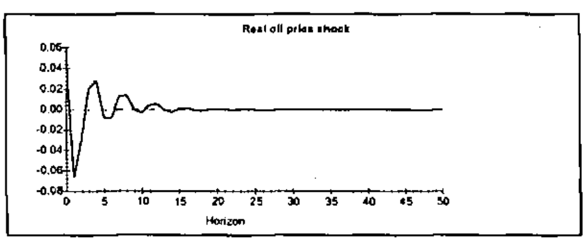
Philippines


Real exchange rate shock
Horizon

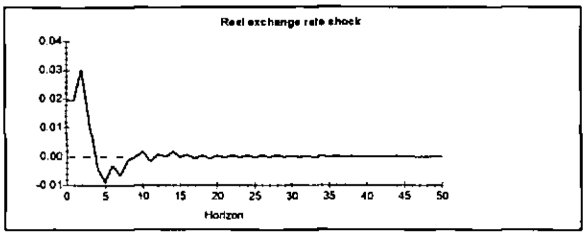

Productivity differential shock
Horizon

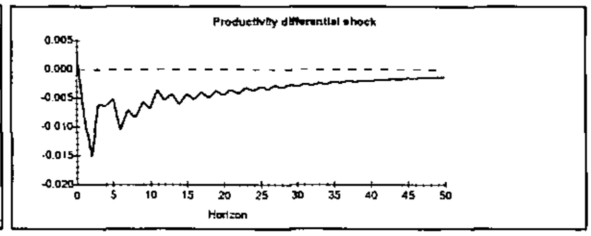

Domestic government spending shock
Horizon

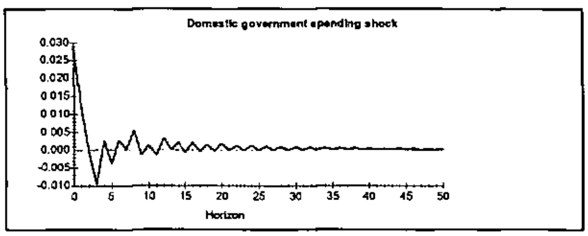

US government spending shock
Horizon

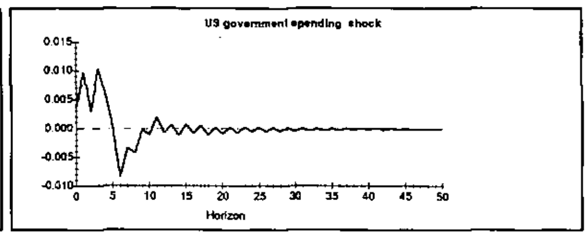

Real oil price shock
Horizon

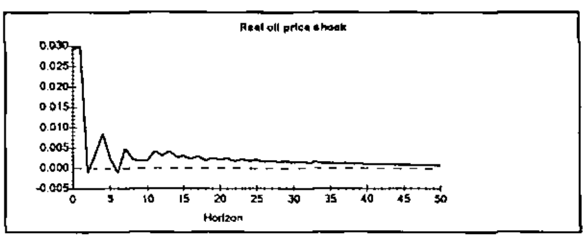
Singapore











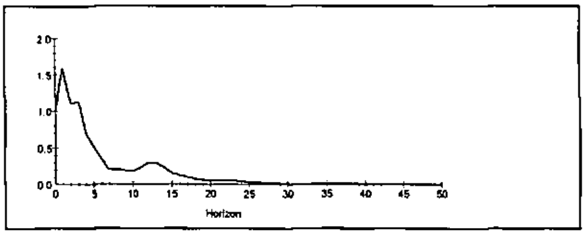
Thailand

(3) Persistence profile analysis

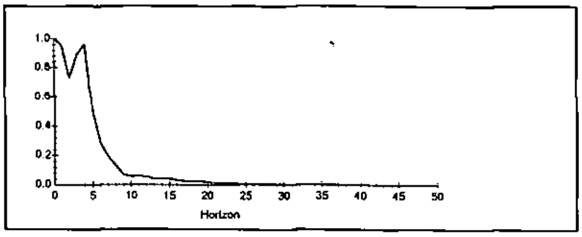
Persistence profiles proposed by Lee and Pesaran (1993) are used to examine the effect of system-wide shocks in causing deviations from the long-run equilibrium relationship. They provide information on whether there are over-shooting effects, and how long, on average, it will take for the economy to settle back into its long-run state following system-wide shocks. Figure 8.3 shows clearly that the long-run relationships have a strong tendency to converge to their respective equilibria. For Indonesia, Japan and Thailand, approximately 80% of adjustment takes place within seven quarters and the full adjustment takes about five years. For the rest of the countries, the 80% adjustment takes less than five quarters and the full adjustment is completed within three years.

Although the results are quite similar in general, the speed of convergence to the long-run equilibrium is faster with system-wide shocks than with individual shocks,[14] which takes approximately 10-24 quarters. This point can bc illustrated by comparing Figures 8.2 and 8.3. These profiles also show a marked over-shooting effect.

Figure 8.3 GI persistence profile of the effect of a system-wide shock to long-run relation

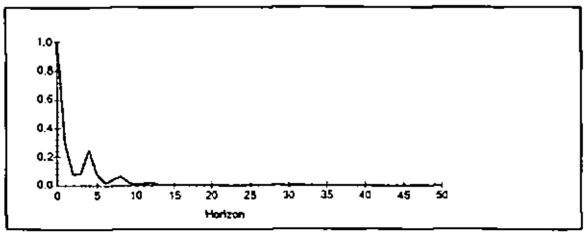


Indonesia

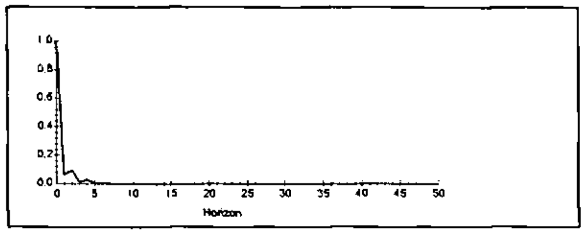


Japan

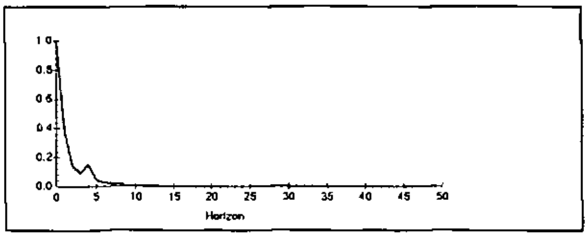
[14] Coakley and Fuertes (1997) explain the reason that the more rapid mean reversion to system-wide shocks may perhaps be explained by synchronised responses to such shocks induced by arbitrage activities.



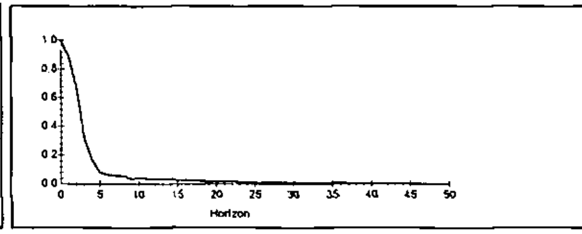
Malaysia



Philippines



Singapore



Thailand

8.3 Conclusion

In this chapter, the innovation accounting technique, i.e. generalised impulse response and forecast error variance decomposition, has been used to trace out the time paths of the real exchange rate to the various shocks on the variables contained in the VAR system, and to measure the relative contributions of each shock to forecast error variance as a function of the forecast horizon. Our analysis revealed that the variances of the real exchange rates are accounted for, to some extent, by the fundamentals and that different disturbances have different degrees of importance for each currency. Specifically, the real price of oil is the most important factor for the Indonesian rapiah, the Japanese yen and the Thai baht; US government spending is the most important for the Philippine peso; and the productivity differential seems an important factor for the Malaysian ringitt and thc Singapore dollar.

The impulse response of real exchange rates and the long-run relationships to one - off shocks has been examined using the generalised impulse response function analysis introduced by Koop *et al* (1996) and developed by Pesaran and Shin (1998). Further, the long-run relationships to system-wide shocks have been investigated by using the persistence profile analysis suggested by Lee and Pesaran (1993). The results show, as expected, that the response of the long-run relationship to shocks is transitory and that the impact of shocks to the real exchange rate is permanent.

The time paths followed in response to the shocks confirm that the real exchange rate may not necessarily revert to its pre-shock equilibrium. Moreover, it takes time, normally three to five years, for the real exchange rate to reach and settle down at the new equilibrium point. Even if the effect of shocks on the long-run relationship is transitory, the speed of convergence to the long-run equilibrium is slow, and, in some cases, takes as long as ten years for convergence, or error-correction, to be completed. All of these leave much room for policy intervention to mitigate unfavourable effects and to achieve desirable outcomes. Nevertheless, as the effects of shocks vary from one country to another, there is no universal panacea to the problems of fluctuations in real exchange rates. Policies will need to recognise the importance of a country's natural endowments, its stage of industrialisation, as well as monetary and exchange conditions.

Chapter 9

Summary and Conclusions

9.1 Summary and conclusions

This thesis has empirically analysed long-run exchange rate movements from several perspectives, focusing specifically on purchasing power parity (PPP) and the non-stationarity of real exchange rates, for a number of East Asian currencies during the recent floating period. The reasons for this choice are twofold. First, as one of the most important building blocks in international economics, PPP forms the core in several models of the exchange rate determination. Nevertheless, there still exist controversies as to its validity. Second, in contrast to the relative abundance of research on the currencies of industrialised countries, very few studies on East Asia have been carried out, leaving many important aspects untackled. Hence, this study provides new empirical findings with valuable policy implications not only for the region but also for the world economy.

Empirical tests on PPP have a long history. Prior to the recent float, the consensus appeared to support the existence of a varying but fairly stable real exchange rate over long periods of time. However, when most of the major industrialised countries abandoned the fixed exchange rate and adopted a flexible one in the late 1970s, high variability of the real exchange rate called into question to the validity of PPP. After the 1980s, the empirical literature mostly rejected PPP, implying that the real exchange rate was non-stationary. A number of reasons were put forward for this with two arguments to the fore. First, the span of available data for the recent floating rate period alone may simply be too short and make the normal statistical tests for non-stationarity of low power. Second, the real exchange rate is likely to be driven by permanent factors so that the nominal exchange rate and the relative prices will tend to deviate permanently from one another, leading to the non-stationary of real exchange rates.

The present study has focused upon the second issue. It has extended the previous research on PPP to the emerging economies in the East Asian region, including Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore and Thailand. The countries experienced the fastest growth rate in the world in the last two decades and also suffered from one of the most severe financial crisis of this century. In the first chapter, a brief introduction to the subject was given, followed by an overview of the economic background in East Asia in chapter 2. Then, three chapters of essential preliminaries were introduced, focusing on the theory and the methodology. In chapter 3, it was shown that in an open economy, if PPP hold, then price levels should move in unison when exchange rates were allowed to move freely. However attractive it might look in theory, PPP turned out to fit the facts very poorly, if at all. In chapter 4 the reasons for the failure of PPP were further investigated, focusing on the role of the relative price of non-tradables. The main concern was whether there exist real factors causing permanent changes in real exchange rate movements and what these real factors are.

Chapter 5 concentrated on the methodology used in the study. The empirical analysis used the recent advances in time series analysis, including unit root tests, the cointegration test of Johansen (1988) and Johansen-Juselius (1990, 1992) likelihood procedure, the vector error correction model, and the innovation accounting technique. The cointegration method is one of the appropriate techniques for testing the validity of long-run PPP hypothesis since it allows for short-run deviations from the long-run level. Further, it does not impose homogeneity restrictions on domestic and foreign prices a priori. The relaxation of parameter restrictions may be a more appropriate test since the homogeneity restriction on price levels may not be reasonable for several reasons including the measurement error and/or existence of transportation costs.

While the cointegration test reveals the relationship between the variables, the vector error correction model displays the speed of adjustment to equilibrium; and the innovation accounting technique, which includes variance decomposition and impulse response analysis, demonstrates the relative importance of shocks in affecting the changes in the real exchange rate and patterns of real exchange rate following the real shocks. Regarding the sample used in this study, it included both the small and large economies, thus it provided an opportunity to assess the different impacts of variables such as fiscal expansion on real exchange rates for different economies.

Under the cointegration framework, the test of PPP amounts to satisfying two conditions. First, the three variables, namely the nominal exchange rate, domestic price level and foreign price level, must be bounded together and form a long-run stable relationship. Second, the coefficients relative to the price levels must satisfy symmetry and proportionality restrictions. When both of the conditions hold, then the strict PPP based on the theory is verified. However, if first condition holds while the symmetry and proportionality fail, it just means that these three variables will not move far apart, and there exists a mechanism between them. In addition to the direct test of PPP, the relationship between the real exchange rate and fundamentals can also be explored via cointegration techniques. If the cointegration relationship among real exchange rate and fundamentals is confirmed, then these variables share the common trend, in other words, there is little tendency for the real exchange rate to be mean-reverting. Hence, it leads to the rejection of the PPP hypothesis.

The next three chapters were concerned with empirical tests. Chapter 6 tested for the simple PPP. In common with the most results from industrialised countries, the unit root tests for the East Asian data confirmed that almost all bilateral real exchange rates contained a unit root, and hence, they were non-stationary, which means they rejected PPP. Moreover, the evidence from the cointegration tests between the nominal exchange rate and domestic and foreign price levels and further imposition of restrictions on the cointegrating vector demonstrated that: on the one hand, the nominal exchange rate and the domestic and foreign prices were cointegrated; and on the other hand, the PPP vector did not exist in the cointegration space. This suggested that there is a long-run comovement between the nominal exchange rate and domestic and foreign prices but these three variables did not move one by one as implied by the theorctical PPP. Thus, the PPP hypothesis was rejected. It also implied that there was little tendency for the real exchange rate to be mean-reverting, and that any deviations from the PPP equilibrium were permanent.

The error correction model indicated that, in the long-run, prices or exchange rates adjusted to correct the short-term deviation from the weak-form PPP. According to our estimates of the error correction coefficients, the burden of adjustment to equilibrium fell on either prices or exchange rates, or both. The signs of the coefficients were as expected in most of the cases and the results also confirmed that the nominal exchange rates responded to disequilibrium more rapidly than prices. This is plausible from a theoretical perspective as the analysis was based on the floating exchange rate period. Economic theory suggests that, under a floating regime, the nominal exchange rate should, in principle, be more responsive than prices in adjusting to equilibrium.

Up to this point the study focused on the simple PPP. However, as was stated above, empirical test of PPP had not been successful in interpreting the movements of real exchange rates for the recent floating period. This led us to investigate further the forces that kept the nominal exchange rate away from the PPP equilibrium, which was carried out in chapter 7. As the aggregate price indices used in testing for PPP include both traded and non-traded goods, there are good reasons that real factors may lead to the permanent changes in real exchange rate movements. According to the existing literature, a number of factors are potentially important in leading to such permanent changes, of which, four factors were considered in our empirical analysis, taking data availability and other considerations into account. These factors, or fundamentals, were productivity differential, domestic and foreign government spending, and the world real price of oil.

Using Johansen-Juselius (1990, 1992) cointegration technique, the results indicated the existence of a stable long-run equilibrium between the real exchange rate and real economic variables. The results were consistent with the view that changes in real variables had significant and persistent influence on the movements of the real exchange rate. The findings again implied that the data were not favourable to a mean- reverting real exchange rate. Factors such as productivity differentials, domestic and US government spending and world real price of oil might cause the systematic deviations from PPP in the countries in our sample. It confirmed that a bias was likely to be introduced to PPP as the factors capture the dominant source of persistent innovations in the real exchange rate.

The reduced form relationship between the real exchange rate and the fundamentals in most of the cases gave estimated coefficients with plausible signs which is consistent with economic theory. The equilibrium real exchange rates appreciated with a rise in productivity differential, domestic government spending, and depreciated with a rise in foreign government spending. The impact of oil shocks on real exchange rates differed across the countries. The coefficient of productivity differential was negative in all the cases, which meant that the faster growth of productivity in the home country relative to the US would lead to an appreciation of the domestic currency in real terms. Also the signs of domestic government spending were broadly as expected, which were negative wherever statistically significant. So the increase of the domestic government spending, which was assumed mostly on non-traded goods, was associated with the appreciation of the real exchange rate in the home country. On the other hand, the sign of the US government spending was positive, so the increase of the US government spending had the opposite effect, which, consequently, led to the depreciation of the home currency. The impacts of the world real price of oil had different effects on different countries, depending on the degree of dependency on imported oil of the two relevant countries as well as the various degrees of exchange rate intervention across countries. Specifically, the results suggested that a real oil price shock might cause real exchange rate depreciation in the cases of Japan, whereas, the real oil shock seemed to lead to the real exchange rate appreciation of Indonesian currency. Regarding these two countries' particular situations, i.e. the former is dependent on imported oil and the latter is oil exporting country, the result was extremely plausible.

Our results also highlighted the importance of productivity differential in leading to permanent changes of real exchange rates for the countries in our sample. In all the cases except Korea, the productivity differential variable was significant and had the largest or second largest coefficient and, therefore, had great impact on real exchange rates. It was, in fact, the most important factor for an appreciation in domestic currencies, which provides support for the Balassa-Samuelson hypothesis. This has profound policy implications beyond the manoeuvres in financial markets and with monetary operations.

Further, the error correction term, which entered the real exchange rate equation, allowed us to assess the stability of the equilibrium relationship among the variables underlying the regression analysis and indicated the speed of adjustment to the equilibrium. Our results revealed, first, that the coefficient of the error correction term in the real exchange rate model was significant in four out of six cases. In other words, the real exchange rate was the endogenous variable in the cointegrated system. Thus the lagged cointegration residual functioned as a proxy for the forces driving changes in the real exchange rate. Second, the sign of the coefficient corresponding to the real exchange rate was, as expected, negative in every case. As a result, whenever there existed disequilibrium with the real exchange rate being above the equilibrium, the real exchange rate would fall to restore the equilibrium relationship in the next period.

Having identified the real shocks, chapter 8 went further and examined the patterns in real exchange rates that followed a specific shock to each variables. It extended the analysis horizon from estimation and model fitting to evaluation on possible future outcomes and performance, with regard to the real exchange rate. The analysis was based on the generalised impulse response and variance decomposition which are invariant to the ordering of the variables in the VAR. The results from variance decomposition revealed that, to some extent, the variance of real exchange rates was accounted for by the fundamentals. It also displayed that different disturbances had different degrees of importance for each of the currencies. Specifically, the world real price of oil was the most important for the Indonesia rapiah, Japanese yen and Thai baht; US government spending was most important for the Philippines peso; and productivity differentials seemed an important factor for the Malaysia ringitt and Singapore dollar.

A pattern had emerged from the impulse responses of real exchange rates and the long-run relationships following one -off shocks using the generalised impulse response function, and the long-run relationships to system-wide shocks using the persistence profile analysis. It revealed, as expected, that the impact of shocks on the real exchange rate was permanent, while the responses of the long-run relationships to both specific shock and system-wide shocks were transitory. The speed of convergence to the long-run equilibrium took approximately 3 to 5 years, on average, and in some cases it took 10 years, which was quite long indeed.

In short, three important conclusions emerged in the study. Firstly, the nominal exchange rate and domestic and foreign price levels were cointegrated, but the PPP vector did not exist in the cointegration space, which implied that any deviation from the PPP equilibrium was permanent and that there was little tendency for the real exchange rate to be mean -reverting;

Secondly, the real exchange rates were cointegrated with real factors, with most of the factors entering the cointegration vector significantly, which suggested that there existed common trend between these variables and that the movements of the real exchange rate were driven by these factors;

Thirdly, impulse response analysis revealed that different disturbances had different degrees of importance for each of the currencies, which mostly depended on a country's natural resources, stage in industrialisation as well as monetary and exchange rate policies.

Exchange rates are important for economic conditions. Changes in exchange rates have pervasive effects, with consequences for prices, wages, interest rates, production levels, and employment opportunities, and thus with direct or indirect implications for the welfare of virtually all economic participants. Accordingly, large and unpredictable changes in exchange rates present a major concern for macroeconomic stabilisation policy.

The present study thus provides important implications for policy purposes. Given the pervasive effects that changes in exchange rates can have on economic conditions, policy makers naturally want to understand what can feasibly be done to limit exchange rate variability, and with what consequences. If PPP holds, it means that exchange rate is only influenced by monetary factors. If this is the case, then they can control exchange rate movements by monetary policy, such as increase or decrease of money stock. However, our study showed that PPP did not hold and that the real exchange rate was affected by real factors. Further scrutiny showed that the patterns of real exchange rates following a real shock are different across the countries. All of these suggested that there is considerable room for policy intervention to mitigate unfavourable effects and achieve desirable outcomes, not just focusing on monetary factors. Nevertheless, as effects to shocks vary from one country to another, there is no universal panacea to the problem of fluctuations in real exchange rates. Thus, it is important for policy makers to focus on each country's specific economic conditions.

9.2 Limitations and further research

Previous studies of the long-run PPP have mainly examined data for industrialised countries, raising the issue of whether the results suffer sample selection bias and exaggerate the general relevance of parity reversion. The present study remedies this limitation by focusing on the East Asian currencies in the time period of the recent float. Various issues on the behaviour of exchange rate have been addressed, adopting the contemporary time series theories and techniques relevant to the long-run PPP, the determinants and the dynamic patterns of real exchange rates. Although the findings and implications are appealing, ambiguities also exist. First is the limitation of the data. A major concern is the measurement of productivity differentials. To offer more convincing interpretations and solutions for productivity differentials, one might use the total factor productivity measure suggested by the theory, or the labour productivity variable instead as most of the studies on industrialised countries have used. Although it is still not clear which variable is a better proxy, both types of data are not available to our case. Thus, the data used here can only provide an approximate measure of productivity differentials, leading to the indirect test of the Balassa-Samuelson effect. An important proxy for the productivity variable is dependent on the new data becoming available. The second limitation is the disaggregate data. To make sure the econometric technique works reasonably well, in the empirical test of the relationship between the real exchange rate and fundamentals, quarterly data rather than annual data were used. However, for some of the time series, such as GDP, only annual data are available for some countries. In the process of disaggregating the data from annual to quarterly, it is likely that there will be inaccuracies. Although we have tried to minimise such inaccuracies, the problem could not be avoided.

The work of this study could also be developed by making use of new econometric methods. Although it is still unclear if PPP holds in the long-run, during the current float, the failure to find support for the long-run PPP highlights a basic testing problem. PPP deviation can be slow to reverse, and conventional econometric techniques have low power to identify stationary but persistent dynamics. Statistical procedures can differ substantially in terms of efficiency and test power, and a more efficient test may require fewer observations to achieve a specific level of power. In this regard, there are tests being developed such as the modified Dickey-Fuller test based on weighted symmetric least squares and with generalised least squares (DF-DLS), which are said to require much shorter sample sizes than conventional tests (c.f. Cheung and Kai, 1998). There are problems, however, as such modified Dickey-Fuller tests have a rather arbitrary in the choice of value for additional parameters in the estimation procedure. Consequently, they may either contribute to an improvement in estimation efficiency if the parameters are chosen correctly, or lead to deterioration in the results otherwise.

The use of multivariate unit root analysis of PPP for panels of data provides another way of overcoming small sample and tend to reject non-stationarity in real exchange rates. However, as Taylor and Sarno (1998) have commented: "while the panel unit root tests may be quite powerful, they must be interpreted with caution", since "such tests may, however, reject joint non-stationarity when just one of the processes is stationary" (p. 283). They found that "for a sample size of around 100, the presence of a single stationary process in a system together with three unit root processes led to rejection, at the 5% level, of the joint null of non-stationarity in about 65% of simulations when the root of the stationary process was as large as 0.95" (p.308). Consequently, there is a bias, sometimes a substantial bias, towards stationarity in such tests. They suggest another test whose null hypothesis is violated only when all of the processes in question are stationary. Although they find evidence that CPI adjusted real exchange rates among the G5 of the US, Britain, Germany, France, and Japan are mean-reverting over the floating rate period, rejection of the joint null of non-stationarity in real exchange rates, constructed using GDP deflators or producer price indices and indicated by the panel unit root test, may be due to only a sub-sample of the series being stationary. O'Connell (1998) has also questioned the reported strong evidence of mean-reversion in real exchange rates, claiming that these studies fail to control for cross-sectional dependence in the data. This failure may raise the significance level of tests with a nominal size of 5 percent to as much as 50 percent. He has shown that, controlling for cross-sectional dependence, no evidence against the random walk null can be found in panels of up to 64 real exchange rates. So, the pendulum is still swinging between real exchange rates stationarity or non-stationarity with a long-memory. As we have argued from the beginning, we believe that there is a role for the fundamentals or real factors to play in determining or influencing the real exchange rate and we cast doubt on the stationarity claim of the real exchange rate, which is close to suggesting that the real exchange rate is rather a monetary process and financial phenomenon. On the other hand, there is a need to incorporate real factors in those long-memory models with a fractional integration procedure, beyond the acceptance or rejection of stationarity in the real exchange rate.

Finally, the present research could be developed to reveal the non-linear adjustment in real exchange rates, concerning transactions costs, see the recent papers by Michael *et al* (1997), Sarantis (1999) and Coakley and Fuertes (1999). Equilibrium models of real exchange rate determination in the presence of transactions costs imply a non-linear adjustment process toward PPP. Conventional cointegration tests, which ignore the effect of transactions costs, may be biased against the long-run PPP hypothesis. If this is the case, then the systematic pattern in the estimates of the non-linear models will provide strong evidence of mean-reverting behaviour for PPP deviations and help explain the mixed results of previous studies.

Clearly, there are a number of improvements that can be made in the future but some of these developments are still of questionable value. These should not detract from the values of the results found within the thesis which provides a very clear rejection of PPP for this particular sample of countries. In fact, existing non-linearity findings do not contradict the results in this thesis. The non-linearity literature has documented random walk like behaviour within a certain band of real exchange rate movements, but there is an increasing tendency of mean-reversion when the real exchange rate is moving close to the boundaries. It is in this sense that PPP may be accepted and the real exchange rate may appear to be stationary. This implies that, within the band and especially away from the boundaries, there is a role for non-stationary real factors to play, and the role would be similar to what have been found in this thesis. On the other hand, the existing non-linearity literature has yet go further to exploit the implications of such behaviour by investigating the role of real factors. Therefore, it is expected that non-linear models may assess the effect of real shocks on the real exchange rate more precisely quantitatively, but may not present qualitatively different results. Improvements can be made on this basis which may benefit the fine-tuning of policy, if it is ever desirable.

Bibliography

Abeysinghe, Y. and Hong, L. K. (1992), Singapore's strong dollar policy and purchasing power parity, *Singapore Economic Review*, 37: 70-79.

Abuaf, N. and Jorion, J. (1990), Purchasing power parity in the long run, *Journal of Finance*, 15: 157-173.

Adler, M. and Lehman, B. (1983), Deviations from purchasing power parity in the long-run, *Journal of Finance*, 39: 1471-1487.

Ahmed, S. (1987), Government spending, the balance of trade and the terms of trade in British history, *Journal of Monetary Economics*, September: 195-220.

Amano, R. A. and Norden, S. (1995), Exchange rates and oil prices, *Working Paper*, No. 95-8, Bank of Canada.

Amano, R. A. and Norden, S. (1998), Oil prices and the rise and fall of the US real exchange rate, *Journal of International Money and Finance*, 17: 299-316.

Asea, P. K. and Corden, W. M. (1994), The Balassa-Samuelson model: An overview, *Review of International Economics*, 2: 191-200.

Baillie, R. T. and McMahon, P. (1989), *The foreign exchange market: theory and econometric evidence*, Cambridge: Cambridge University press.

Baillie, R. T and Selover, D. D. (1987), Cointegration and models of exchange rate determination, *International Journal of Forecasting*, 3: 43-51.

Baharumshah, A. Z. and Ariff, M. (1997), Purchasing power parity in South East Asian countries economies: A cointegration approach, *Asian Economic Journal*, 11: 141-53.

Bahmani-Oskooee, M and Rhee, H (1996), Time-series support for Balassa's productivity-bias hypothesis: evidence from Korea, *Review of International Economics*, 4: 364-370.

Bahmani-Oskooee, M. (1998), Do exchange rates follow a random walk process in Middle Eastern countries? *Economics Letters*, 58: 339-44.

Balassa, B. (1964), The purchasing power parity doctrine: A reappraisal, *Journal of Political Economy*, 72: 584-96.

Banerjee, A., Hendry, D. F. and Smith G. W. (1986), Exploring equilibrium relationship in econometrics through static models: Some Monte Carlo evidence, *Oxford Bulletin of Economics and Statistics*, 52: 95-104.

Banerjee, A., Dolado, J. J., Galbraith, J. W., and Hendry, D. F. (1993), *Co-Integration, error Correction, and the econometric analysis of non-stationary data*, New York: Oxford University Press.

Becketti, S., Hakkio, C. S. and Joines, D. H. (1995), Exchange rates in the long run, *Working Paper*, RWP 95-14, Federal Reserve Bank of Kansas City.

Bhagwati, J. (1984), Why are services cheaper in the poor countries? *Economic Journal*, 94: 278-86.

Bleaney, M. and Mizen, P. (1995), Empirical tests of mean reversion in real exchange rates: A survey, *Bulletin of Economic Research*, 47: 171-195.

Blomberg, S. B. and Hess, G. D. (1996), Politics and exchange rate forecasts, *Working Paper*, RWP 96-02, Federal Reserve Bank of Kansas City.

Boot, J. C. G., Feibes, W. and Lisman, J. H. C. (1967), Further methods of derivation of quarterly figures from annual data, *Applied Statistics*, 16: 65-75.

Breuer, J. B. (1994), An assessment of the evidence on purchasing power parity, In Williamson, J. (ed.), *Equilibrium exchange rates*, Institute for International Economics, Washington, DC, p. 254-77.

Campbell, J. Y. and Perron, P. (1991), Pitfalls and opportunities: what macroeconomists should know about the unit roots, *in* Oliver Jean Blanchard and Stanley Fischer (eds.), *NBER Economics Annual*, Cambridge: MIT Press.

Campbell, J. Y., Lo, A. W. and MacKinlay. A. C. (1997), *The econometrics of financial markets*, Princeton, New Jersey: Princeton University Press.

Canzoneri, M. B. and Cumby, R. E. and Diba, B. (1999), Relative labour productivity and the real exchange rate in the long-run: evidence for a panel of OECD countries, *Journal of International Economics*, 47: 245-66.

Cassel, G. (1922), *Money and foreign exchange after 1914*, London: MacMillan.

Chaudhuri, K. and Daniel, B. C. (1998), Long-run equilibrium real exchange rates and oil prices, *Economics Letters*, 56: 231-238.

Chen, B. (1995), Long-run purchasing power parity: evidence from some European Monetary System countries, *Applied Economics*, 27: 377-383.

Cheung, Y. and Lai, K. (1993), Long-run purchasing power parity during the recent float, *Journal of International Economics*, 34: 181-192.

Cheung, Y. and Lai, K. (1993), A fractional cointegration analysis of purchasing power parity, *Journal of Business and Economic Statistics*, 11: 103-12.

Cheung, Y. and Lai, K. (1998), Parity reversion in real exchange rates during the post-Bretton Woods period, *Journal of International Money and Finance*, 17: 597-614.

Cheung, Y, Fung, H., Lai, K. and Lo, W (1995), Purchasing power parity under the European Monetary System, *Journal of International Money and Finance*, 14: 179-189.

Chinn, M. D. (1996), Asian-Pacific real exchange rates and relative prices, *Working Paper*, No. 358, Department of Economics, University of California, Santa Cruz.

Chinn, M. D. (1997), The usual suspects? productivity and demand shocks and Asia-Pacific real exchange rates, *NBER Working Papers*, No. 6108.

Chinn, M. D. (1998), Before the fall: Were East Asian currencies overvalued, *NBER Working Papers,* No. 6491.

Chinn, M and Johnston, L. (1997), Real exchange rate levels, Productivity and demand shocks: evidence from a panel of 14 countries, *International Monetary Fund Working Papers*, WP/97/66.

Choudry, T., McNown, R. and Wallace, M. (1991), Purchasing power parity and the Canadian float in the 1950s, *Review of Economics and Statistics*, 73: 558-63.

Chowdhury, A. R. and Sdogati, F. (1993), Purchasing power parity in the major European Monetary System countries: the role of price and exchange rate adjustment, *Journal of Macroeconomics*, 15: 25-45.

Clague, C. and Tanzi, V. (1972), Human capital, natural resources and the purchasing power parity doctrine: some empirical results, *Economia Internationale*, 25: 3-18.

Coakley, J. and Fuertes, A.M. (1997), New panel unit root tests of PPP, *Economics Letters*, 57: 17-22.

Coakley, J. and Fuertes, A.M. (1997), Reevaluating relative PPP in an OECD panel 1973-96', *Center for International Capital Markets Discussing Papers*, No. 97-04, London Guildhall University.

Coakley, J. and Fuertes, A.M. (1999), Short run exchange rate dynamics, *The Manchester School,* Forthcoming.

Coakley, J. and Fuertes, A.M. (1999), Border costs and real exchange rate dynamics in Europe, *Birkbeck College Discussion Paper in Economics*, No. 20/99.

Cochrane, J. Y. (1988), How big is the random walk in GNP? *Journal of Political Economy*, 96: 893-920.

Cochrane, S. J. and DeFina, R. H. (1995), Predictable components in exchange rates, *The Quarterly Review of Economics and Finance*, 35: 1-14.

Corbae, D. and Ouliaris, S. (1988), Cointegration tests of purchasing power parity, *Review of Economics and Statistics*, 55: 508-11.

Coughlin, C. and Koedijk, K. (1990), What do we know about the long-run real exchange rate? *Economic Review*, January/February, Federal Reserve bank of St. Louis.

Crownover, C., Pippenger, J. and Steigerwald, D. G. (1996), Testing for absolute purchasing power parity, *Journal of International Money and Finance*, 15: 783-96.

Cumby, R. E. and Obstfeld, M. (1984), International interest rate and price level linkage under flexible exchange rates: Review of recent evidence, in John F.O. Bilson and Richard C. Marston (eds.), *Exchange rate Theory and Practice,* Chicago: University of Chicago Press, p. 121-51.

Darby, M. (1983), Movements in purchasing power parity: The short and long runs, in M. Darby and J. Lothian (eds.), *The international transmission of inflation,* Chicago: University of Chicago Press.

DeLoach, S. B. (1996), Do relative prices of non-traded goods determine long-run real exchange rates? *Canadian Journal of Economics*, 30: 891-909.

De Vries, M. G. (1968), Exchange rate depreciation in developing countries, *International Monetary Fund Staff Papers,* 15: 560-78.

DeGregorio, J., Giovaninini, A. and Krueger, T. (1994), The behavior of non-tradable goods prices in Europe: evidence and interpretation, *Review of International Economics*, 2: 284-305.

DeGregorio, J., Giovaninini, A. and Wolf, H. (1994), International evidence on tradables and nontradables inflation, *European Economic Review*, 38: 1225-44.

DeGregorio, J and Wolf, H. (1994), Terms of trade, productivity, and the real exchange rate, *NBER Working Papers*, No. 4807.

Dibooglu, S. (1996), Real disturbances, relative prices and purchasing power parity, *Journal of Macroeconomics*, 18: 69-87.

Dibooglu, S. and Enders W. (1995), Multiple cointegration vectors and structural economic models: an application to the French franc/US dollar exchange rate, *Southern Economic Journal*, 6: 1098-1116.

Dickey, D. A. and Fuller, W. A. (1979), Distribution of the estimators for autoregressive time series with a unit root, *Journal of American Statistical Association*, 74: 423-31.

Dickey, D. A. and Fuller, W. A. (1981), Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica*, 49: 1057-1072.

Diebold, F. X., Husted, S. and Rush, M. (1991), Real exchange rates under the Gold Standard, *Journal of Political Economy*, 99: 1252-71.

Dohner, R and Intal, P. (1989), The Macros legacy: Economic policy and foreign debt in the Philippines, in J. Sachs (ed.), *Developing country debt and economic performance*, Chicago.

Dornbusch, R. (1976), Expectations and exchange rate dynamics, *Journal of Political Economy*, 84: 1161-1176.

Dornbusch, R. (1980), Exchange rate economics: where do we stand? *Brookings Papers on Economic Activity*, 1, 143-194.

Dornbusch, R. (1987), Purchasing power parity, in Watwell, J., Migare, M., and Newman, P. (eds), *The New Palgrave Dictionary* (3rd. ed.), New York: Stockton Press, 3: 1075-87

Dueker, M. J. (1993), Hypothesis testing with near-unit roots: The case of long-run purchasing power parity, *Working Papers*, July/August, Federal Reserve Bank of St. Louis.

Dutton, M. (1998), Are the CPI and WPI appropriate measures to use for testing the PPP hypothesis? *Studies in Economics and Finance*, 18: 62-99.

Dutton, M and Strauss, J (1997), Cointegration tests of purchasing power parity: The impact of non-traded goods, *Journal of International Money and Finance*, 16: 433-44.

Edison, H. (1987), Purchasing power parity in the long-run: A test of dollar/pound exchange rate: 1890-78, *Journal of Money, Credit, and Banking*, 19: 376-87.

Edison, H. Gagnon, J. and Melick, W. (1997), Understanding the empirical literature on purchasing power parity: the post - Bretton Woods era, *Journal of International Money and Finance*, 16: 1-17.

Edison , H. and Fisher, E. O'N. (1991), A long run view of the European Monetary System, *Journal of International Money and Finance*, 10:53-70.

Edison, H. and Klovland, J. T. (1987), A quantitative reassessment of the purchasing power parity hypothesis: evidence from Norway and the United Kingdom, *Journal of Applied Econometrics*, 2: 309-33.

EIU (1998), Country profile, *The Economist Intelligence Unit Limited*, various issues.

Enders, W. (1988), ARIMA and cointegration tests of PPP under fixed and flexible exchange rate regimes, *Review of Economics and Statistics*, 31: 504-8.

Enders, W. (1995), *Applied econometric time series*, Wiley.

Engel, C. (1995), Accounting for US real exchange rate changes, *NBER Working Papers*, No. 5394.

Engel, C. (1996), Long-run PPP may not hold after all, *NBER Working Papers*, No. 5646.

Engle, R. F. and Granger, C. W. J. (1987), Cointegration and error correction: representation, estimation and testing, *Econometrica*, 55: 251-276.

Faruqee, H. (1995), Pricing to market and the real exchange rate, *International Monetary Fund Working Papers*, WP/95/12.

Feenstra, R. C and Kendall, J. P. (1997), Pass-through of exchange rates and purchasing power parity, *Journal of International Economics*, 43: 237-61.

Feyzioglu, T. (1997), Estimating the equilibrium real exchange rate: an application to Finland, *International Monetary Fund Working Papers*, WP/97/109.

Fisher, E. O'N and Park, J. Y (1991), Testing purchasing power parity under the null hypothesis of co-integration, *Economic Journal*, 101: 1476-84.

Flynn, N.A. and Boucher, J. L. (1993), Tests of long run purchasing power parity alternative methodology, *Journal of Macroeconomics*, 15: 109-22.

Frankel, J. A. (1986), International capital mobility and crowding out in the US economy: imperfect integration of financial markets or of goods markets, In R. W. Hafer (ed.), *How Open Is the US Economy*? Lexington, MA.

Frankel, J. A. and Meese, R. (1987), Are exchange rates excessivcly variable? In Fisher, S. (ed.), *NBER Macroeconomics Annual*, Cambridge, MA: MIT Press, p. 117-153.

Frankel, J. A. and Mussa, M. (1980), The efficiency of foreign exchange markets and measures of turbulence, *American Economic Review*, 70: 374-81.

Frankel, J. A. and Rose, A. K. (1994), A survey of empirical research on nominal exchange rates, *NBER Working Papers*, No. 4865.

Frankel, J. A. and Rose, K. (1996), A panel project on PPP: mean revision within and between countries, *Journal of International Economic*, 40: 209-224.

Frenkel, J. A. (1978), Purchasing power parity doctrinal perspective and evidence from the 1920s, *Journal of International Economics*, 8: 169-191.

Frenkel, J. A. (1981), The collapse of purchasing power parity during the 1970s, *European Economic Review*, 16: 145-165.

Frenkel, J. A. and Johnson, H. G. (1978), *The economics of exchange rates*, Reading, Mass.: Addison-Wesley.

Frenkel, J. A. and Razin, A. (1992), Fiscal policies and the world economy (2nd ed.), Cambridge, MA: MIT Press.

Froot, K. A. and Rogoff, K. (1991), The European , the EMU and the transition to a common currency, in Stanley Fischer and Olivier Blanchard (eds.), *NBER Macroeconomics Annual*, Cambridge, MA: MIT Press, p. 269-317.

Froot, K. A. and Rogoff, K. (1994), Perspectives on PPP and long-run real exchange rates, *NBER Working Papers*, No. 4952.

Fuller, W. A. (1976), *Introduction to statistical time series*, New York: Wiley.

Genberg, H. (1978), Purchasing power parity under fixed and flexible exchange rates, *Journal of International Economics*, 8: 247-76.

Ghysels, E. (1990), Unit-roots and the statistical pitfalls of seasonal adjustments: The case of US post-war real gross national product, *Journal of Business and Economic Statistics*, 8: 145-152.

Gil-Alana, L. A. (1998), Fractional integration in the purchasing power parity, *Working Papers*, No. 98/18, European University Institute.

Glen, J. D. (1992), Real exchange rates in the short, medium and long-run, *Journal of International Economics*, 33: 147-66.

Granger, C. W. J. (1983), Cointegrated variables and error-correcting models, *Discussion Papers*, University of California, San Diego.

Granger, C. W. J. (1986), Developments in the study of cointegrated economic variables, *Oxford Bulletin of Economics and Statistics*, 48: 213-228.

Granger, C. W. J. (1988) A, Some Recent Developments in a Concept of Causality, *Journal of Econometrics*, 39:199-211.

Granger, C. W. J. (1988), Causality, Cointegration and Control, *Journal of Economic Dynamics and Control*, 12: 551-559.

Grauwe, P. D. (1996), *International money - Postwar trends and theories* (2nd ed.), New York: Oxford University Press.

Grunwald, J. and Salazar-Carrillo, J (1972), Economic integration, rates of exchange, and value comparison in Latin American, in D. J. Daly (ed.), *International Comparisons of Prices and Output*, New York: NBER, p. 227-80.

Grilli, V and Kaminsky, G. (1991), Nominal exchange rate regimes and the real exchange rates: evidence from the United Stated and Great Britain, 1885-1986, *Journal of Monetary Economics*, 27: 191-212.

Hallwood, C. P. and MacDolnald, R. (1994), *International money and finance* (2nd ed.), Oxford: Basil Blackwell, USA.

Hakkio, C. (1984), A reexamination of purchasing power parity, *Journal of International Economics*, 17: 265-277.

Hakkio, C. (1986), Does the exchange rate follow a random walk? A Monto Carlo study of four tests for random walk, *Journal of International Money and Finance*, 5: 221-229.

Henricsson, R. and Lundsack, E. (1995), Testing the presence and the absence of purchasing power parity: results for fixed and flexible regimes, *Applied Economics*, 27: 635-641.

Hooper, P. and Morton, J. (1982), Fluctuations in the Dollar: a model of nominal and real exchange rate determination, *Journal of International Money and Finance*, 1: 39-56.

Hsieh, D. A. (1982), The determination of the real exchange rate - The productivity approach, *Journal of International Economics*, 12: 355-362.

In, F. and Sugema, I. (1995), Testing purchasing power parity in a multivariate cointegrating framework, *Applied Economics*, 27: 891-899.

In, F. and Menon, J. (1996), The long-run relationships between real exchange rate and terms of trade in OECD countries, *Applied Economics*, 28: 1075-1080.

Isard, P. (1995), *Exchange rate economics*, Cambridge: Cambridge University Press.

Isard, P. and Symansky, S. (1996), Long-run movements in real exchange rates, In Takatoshi Ito, Peter Isard, Steven Symanskt and Tamim Bayoumi (eds.), *Exchange rate movements and their impact on trade and investment in the APEC region*, Occasional Paper, No. 145, Washington, D.C., International Monetary Fund.

Ito, T., Isard, P. and Symansky, S. (1997), Economic growth and real exchange rate: An overview of the Balassa-Samuelson hypothesis in Asia, *NBER Working Papers*, No. 5979.

Johansen, S. (1988), Statistical analysis of cointegration vectors, *Journal of Economic Dynamics and Control*, 12: 231-54.

Johansen, S. (1991), Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models, *Econometrica*, 59: 1551-80.

Johansen, S. and Juselius, K. (1990), Maximum likelihood estimation and inferences on cointegration - with application to the demand for money, *Oxford Bulletin of Economics and Statistics*, 52: 169-210.

Johansen, S. and Juselius, K. (1992), Testing structural hypothesis in a multivariate cointegration analysis of the PPP and the UIP for UK, *Journal of Econometrics*, 53: 211-244.

Juselius, K. (1995), Do purchasing power parity and uncovered interest parity hold in the long run? An example of the likelihood inference in a multivariate time-series model, *Journal of Econometrics*, 69: 211-240.

Jorion, P and Sweeney, R. J. (1996), Mean reversion in real exchange rates: evidence and implications for forecasting, *Journal of International Money and Finance*, 15: 535-550.

Kahn, B. and Parikh, A. (1998), Does purchasing power parity survive political shocks in South African? Weltwirtschaftliches Archiv, 134: 99-116.

Kasa, K. (1992), Adjustment costs and pricing to market: Theory and evidence, *Journal of International Economics*, 32: 1-30.

Kim, I. J. (1995), Cointegration testing of multi-country purchasing power parity: The case of Korea, *Seoul Journal of Economics*, 8: 425-41.

Kim, J and Enders, W. (1991), Real and monetary causes of real exchange rate movements in the Pacific Rim, *Southern Economic Journal*, 57: 1061-71.

Knetter, M. M. (1989), Price discrimination by US and German exporters, *American Economic Review*, 79: 198-210.

Knetter, M. M. (1993), International comparisons of price-to-market behavior, *American Economic Review*, 83: 473-86.

Koedijk, K. G. and Schotman, P. (1990), How to beat the random walk - An empirical model of real exchange rates, *Journal of International Economics*, 29: 311-332.

Koedijk, K. G., Schotman, P. and Dijk, M. A. (1998), The re-emergence of PPP in the 1990s, *Journal of International Money and Finance*, 17: 51-61.

Koop, G., Pesaran, M. H. and Potter, S. M. (1996), Impulse response analysis in nonlinear multivariate models, *Journal of Econometrics*, 17: 107-12.

Koray, F. and Chan, P. (1991), Government spending and exchange rate, *Applied Economics*, 23: 1551-58.

Kravis, I. B. and Lipsey, R. E. (1978), Price behaviour in the light of balance of payments theories, *Journal of International Economics*, 8: 193-246.

Kravis, I. B. and Lipsey, R. E. (1983), Toward an explanation of national price levels, *Princeton studies in International Finance*, No. 52.

Kremers, Jereon J. M., Ericsson, N. R. and Dolado, J. J. (1992), The power of cointegration tests, *Oxford Bulletin of Economics and Statistics*, 54: 325-48.

Krugman, P. (1978), Purchasing power parity and exchange rates: Another look at the evidence, *Journal of International Economics*, 8: 397-407.

Krugman, P. (1983), Oil and the dollar, in Jagdeep S. Bhandari and Bluford Putnam (eds.) *Independence and Flexible Exchange Rates*, Cambridge, Massachusetts: MIT Press.

Krugman, P. (1987), Pricing to market when the exchange rate changes, in Sven W. Arndt and J. David Richardson (eds.), *Real financed linkages among open economies*, Cambridge, MA: MIT Press, p: 49-70.

Krugman, P. (1990), Equilibrium exchange rates, in William H. Branson, Jacob A. Frenkel, and Morris Goldstein (eds.), *International monetary policy corridniation and exchange rate fluctuations*, Chicago Press, p: 158-87.

Krugman, P. and Obstfeld, M. (1994), *International economics theory and policy* (4th eds.), New York: Harper Collins College Publishers.

Kugler, P. and Lenz, C. (1993), Multivariate cointegration analysis and the long-run validity of purchasing power parity, *Review of Economics and Statistics*, 75: 180-184.

Kwiatrowski, D, Philipps, P. C. S., Schimdt, P. and Shin, Y. (1992), Testing the null hypothesis of stationary against the alternative of a unit root: how sure are we that economic time series have a unit root? *Journal of Econometrics*, 54: 159-38.

Layton, A. P. and Stark, J. P. (1990), Co-integration as an empirical test of purchasing power parity, *Journal of Macroeconomics*, 12: 125-36.

Lee, K. and Pesaran, M. H. (1993), Persistence profiles and business cycle fluctuations in a disaggregated model of UK output growth, *Richerche Economiche*, 47: 293-322.

Lim, G. C. (1992), Testing for the fundamental determinants of the long-run real exchange rate, *Journal of Banking and Finance*, 16: 625-42.

Lin, C. Y. and He, J. (1991), Do real exchange rates follow random walks: A heteroscedasticity-robust autocorrelation test, *International Economic Journal*, 5: 39-48.

Liu, P. C. and Maddala, G. S. (1996), Do panel data cross-country regression rescue purchasing power parity (PPP) theory? *Working Papers*, Department of Economics, Ohio State University.

Lo, A. W. and Mackinlay, A. C. (1988), Stock market prices do not follow random walks: Evidence from a simple specification test, *Review of Financial Studies*, 1: 41-66.

Lothian, J. R. (1990), A century plus of yen exchange rate behavior, *Japan and the World Economy*, 2: 47-70.

Lothian, J. R. (1997), Multi - country evidence on the behavior of purchasing power parity under the current float, *Journal of International Money and Finance*, 16: 19-35.

Lothian, J. R. (1998), Some new stylized facts of floating exchange rates, *Journal of International Money and Finance*, 17: 29-39.

Lothian, J. R. and Taylor M. P. (1996), Real exchange rate behavior: The recent float from the perspective of the past two centuries, *Journal of Political Economy*, 104: 488-509.

Lothian, J. R. and Taylor M. P. (1997), Real exchange rate behavior, *Journal of International Money and Finance*, 16: 945-954.

Lükepohl, H. (1991), *Introduction to multiple time series analysis*, New York: Springer-Verlag.

Lükepohl, H. and Reimers, H. E. (1992), Impulse response analysis of cointegrated system, *Journal of Dynamic and Control*, 16: 53-78.

MacDonald, R. (1993), Long-run purchasing power parity: Is it for real? *Review of economics and statistics*; 75: 690-95.

MacDonald, R. (1995), Long-run exchange rate modelling - A survey of the recent evidence, *International Monetary Fund Staff Papers*, 42: 437-489.

MacDonald, R. (1996), Panel unit root tests and real exchange rates, *Economics Letters*, 50: 7-11.

MacDonald, R. (1997), What determines real exchange rates: The long and short of it? *International Monetary Fund Working Papers*, WP/97/21.

MacDonald, R. and Taylor, M. P. (1992), Exchange rate economics - a survey, *International Monetary Fund Staff Papers*, 39: 1-53.

Mahdavi, S. and Zhou, S. (1994), Purchasing power parity in high-inflation countries: Further evidence, *Journal of Macroeconomics*, 16: 403-422.

Mansur, M. and Ariff, M. (1995), Purchasing power parity: new method and extensions, *Applied Financial Economics*, 5: 19-26.

Mark, N. C. (1990), Real and nominal exchange rates in the long run: An empirical investigation, *Journal of International Economics*, 28: 115-36.

Mark, N. C. (1995), Exchange rates and fundamentals: evidence on long-horizon predictability, *American Economic Review*, 85: 201-18.

Mark, N. C. and Choi, D. Y. (1997), Real exchange rate prediction over long horizons, *Journal of International Economics*, 31: 29-60.

Marston, R. (1987), Real exchange rates and productivity growth in the United States and Japan, in S. Arndt and J. D. Richardson (eds.), *Real financial linkages among open economies,* Cambridge, MA: MIT Press, p. 71-96.

Marston, R. (1990), Systematic movements in real exchange rates in the G-5: Evidence on the integration of intemal and extemal markets, *Journal of Banking and Finance*, 14: 1023-44.

Marston, R. (1990), Pricing to market in Japanese manufacturing, *Journal of International Economics*, 29: 217-36.

Mellander, E. Vredin, A and Warne, A. (1992), Stochastic trends and economic fluctuations in a small open economy, *Journal of Applied Econometrics*, 7: 369-94.

McGuirk, A. (1983), Oil price changes and real exchange rate movements among industrial countries, *International Monetary Fund Staff Papers*, p. 843-84.

McNown, R. and Wallace, M. S. (1989), National price levels, purchasing power parity and cointegration: a test for four high inflation economies, *Journal of International Money and Finance*, 8: 533-45.

McNown, R. and Wallace, M. S. (1994), Cointegration tests of the monetary exchange rate model for three high-inflation economies, *Journal of Money, Credit and Banking*, 26: 396-411.

Meese, R. and Rogoff, K. (1988), Was it real? The exchange rate interest differential relation over the modem floating exchange rate period, *Journal of Finance*, 43: 933-948.

Michael, P, Nobay, A. R. and Peel, D.A. (1997), Transactions costs and nonlinear adjustment in real exchange rates: An empirical investigation, *Journal of Political Economy*, 105: 862-879.

Micossi, S. and Milesi-Ferretti, G. M. (1994), Real exchange rates and the prices of nontradable goods, *International Monetary Fund Working Papers,* WP/94/19.

Mills, J. and Prasad, K. (1992), Comparison of model selection criteria, *Econometric Reviews*, 11: 201-33.

Montiel, P. J. (1997), Exchange rate policy and macroeconomic management in ASEAN countries, in Hicklin, J., David Robinson and Anoop Singh (eds.), *Macroeconomic Issues facing ASEAN countries*, Intemational Monetary Fund, p.253-296.

Moosa, I. A. and Bhatti, R. H. (1997), Are Asian markets integrated? Evidence from six countries *vis-à-vis* Japan, *International Economic Journal*, 11: 51-67.

Mussa, M. L. (1986), Nominal exchange rate regimes and the behavior of real exchange rates: evidences and implications, in K. brunner and A. H. Melzer (eds.), *Real business Cycles, real* *exchange rates and actual polices,* Carnegie-Rochester Conference Series on Public Policy, 25: 117-214.

Myhran, J. (1976), Experiences of flexible exchange rates in earlier periods: Theories, evidence and a new view, *Scandinavian Journal of Economics*, 78: 169-96.

Obstfeld, M and Rogoff, K. (1995), The intertemporal approach to the current account, in Gene Grossman and kenneth Rogoff (Eds.), ?? p: 1737-99.

O'Connell, P. G. J. (1998), The overvaluation of purchasing power parity, *Journal of International Economics*, 44: 1-19.

OECD, Economic Surveys, various issues.

Officer, L. H. (1972), The productivity bias in purchasing power parity: An econometric investigation, *International MonetaryFund Staff Papers,* 23: 545-79.

Officer, L. H. (1976), The purchasing power parity theory of exchange rates: A review article, *International Monetary Fund Staff Papers*, 23: 1-60.

Officer, L. H. (1982), *Purchasing power parity and exchange rates: Theory, evidence and relevance*, Greenwich, Connecticut: JAI Press.

Oh, K. Y. (1996), Purchasing power parity and unit root tests using panel data, *Journal of International Money and Finance*, 15: 405-418.

Ohno, K. (1989), Testing purchasing power parity and the Dornbusch overshooting model with vector autoregression, *Journal of the Japanese and International Economics*, June, p. 209-26.

Osterwald-Lenum, M. (1992), A note with quartiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics, *Oxford Bulletin of Economics and Statistics*, 54: 461-472.

Ott, M. (1996), Post Bretton Woods deviations from purchasing power parity in G7 exchange rates - an empirical exploration, *Journal of International Money and Finance*, 15: 899-924.

Papell, D. H. (1997), Searching for stationary: purchasing power parity under the current float, *Journal of International Economics*, 43: 313-332.

Papell, D. H. and Theodoridis, H. (1998), Increasing evidence of purchasing power parity over the current float, *Journal of International Money and Finance*, 17: 41-50.

Park, J. Y. (1990), Testing for unit roots and cointegration by variable addition, In Thomas B Formby and George F Rhodes, (eds.), *Spurious regression, and unit roots: advances in econometrics*, Greenwich, Connecticut and London: JAF Press.

Parsley, D. C. and Wei, S. J. (1996), Convergence to the law of one price without trade barriers of currency fluctuations, *Quarterly Journal of Economics*, 8: 1211-36.

Patel, J. (1990), Purchasing power parity as a long run relation, *Journal of Applied Econometrics*, 5: 367-79.

Perron, P and Vogelsang, T. J. (1992), Nonstationarity and level shifts with an application of purchasing power parity, *Journal of Business and Economic Statistics*, 10: 301-20.

Pesaran, M. H. and Shin, Y. (1996), Cointegration and the speed of convergence to equilibrium, *Journal of Econometrics*, 71: 117-43.

Pesaran, M. H. and Smith, R. (1995), The role of theory in econometrics, *Journal of Econometrics*, 67: 61-79.

Pesaran, M. H. and Shin, Y. (1998), Generalized impulse response analysis in linear multivariate models, *Economics Letters*, 58: 17-29.

Phillips, P. C. B. (1987), Time series regression with a unit root, *Econometrica*, 55: 277-301.

Phillips, P. C. B. (1991), Optimal inference in cointegrated systems, *Econometrica*, 59: 283-306.

Phillips, P. C. B. and Perron, P. (1988), Testing for unit root in time series regression, *Biometrika*, 578: 165-93.

Phillips, P. C. B. and Loretan, M. (1991), Estimating long-run economic equilibria, *Review Economics Studies*, 59: 407-36.

Phylaktis, K. (1992), Purchasing power parity and cointegration: the Greek evidence from the 1920s, *Journal of International Money and Finance*, 11: 502-13.

Phylaktis, K. and Kassimatis, Y. (1994), Does the real exchange rate follow a random walk? The Pacific Basin perspective, *Journal of International Money and Finance*, 13: 476-495.

Pilbeam, K. (1992), *International finance*, London: Macmillan Press.

Pippenger, M. K. (1993), Cointegration tests of purchasing power parity: The case of the Swiss exchange rate, *Journal of International Money and Finance*, 12: 46-61.

Rogers, J. H. and Jenkins, M. (1995), Haircuts or hysteresis? Sources of movements in real exchange rates, *Journal of International Economics*, 38: 339-360.

Rogoff, K. (1991), Oil, productivity, government spending and the real yen exchange rate, *Working Papers*, PB 91-06, Federal Reserve Bank of San Francisco.

Rogoff, K. (1992), Traded goods consumption smoothing and the random walk behavior of the real exchange rate, *Bank of Japan Monetary and Economic Studies*, 10: 1-29.

Rogoff, K. (1996), The purchasing power parity puzzle, *Journal of Economic Literature*, 34: 647-668.

Samuelson, P. (1964), Theoretical notes on trade problem, *Review of Economics and Statistics*, 46: 145-54.

Sarantis, N. (1999), Modelling non-linearities in real effective exchange rates, *Journal of International Money and Finance*, 18: 27-45.

Sarantis, N. and Stewart, C. (1993), Seasonality, cointegration and the long-run purchasing power parity: Evidence for sterling exchange rates, *Applied Economics*, 25: 243-250.

Sarno, L. and Taylor, M. P. (1998), Real exchange rates under the recent float: Unequivocal evidence of mean reversion, *Economics Letters*, 60: 131-137.

Sideris, D. (1997), Multilateral versus bilateral testing for long-run purchasing power parity: A cointegration analysis for the Greek drachma, *Working Papers*, No. 97/18, European University Institute.

Sim, C. (1980), Macroeconomics and reality, *Econometrica*, 48: 1-48.

Sim, C. (1981), An autoregressive index model for the US 1948-1975, in J. B. Ramsey (ed.), *Large-Scale Econometric Models*, North-Holland, The Netherlands.

Soofi, A. S. (1998), A fractional cointegration test of purchasing power parity: the case of selected members of OPEC, *Applied Financial Economics*, 8: 559-66.

Strauss, J. (1995), Real exchange rates, PPP and the relative price of nontraded goods, *Southern Economic Journal*, 61: 991-1005.

Strauss, J. (1996), The cointegrating relationship between productivity, real exchange rates and purchasing power parity, *Journal of Macroeconomics*, 18: 299-313

Strauss, J. (1999), Productivity differentials, the relative price of non-tradables and real exchange rates, *Journal of International Money and Finance*, 18: 383-409.

Stock, J. and Watson, M. (1993), A simple estimator of cointegrating vectors in higher order integrated systems, *Econometrica*, 61: 783-820.

Taylor, M. P. (1988), An empirical examination of long run Purchasing Power Parity using cointegration techniques, *Applied Economics*, 20: 1369-81.

Taylor, M. P. (1995), The economics of exchange rates, *Journal of Economic Literature*, 33: 13-47.

Taylor, M. P. and McMahon, P. (1988), Long run purchasing power parity in the 1920s, *European Economic Review*, 32: 179-197.

Thacker, N. (1995), Does PPP hold in the transition economies? The case of Poland and Hungary, *Applied Economics*, 27: 477-481.

Tongzou, J. L. (1998), *The economics of Southeast Asia - The growth and development of ASEAN*, Edward Elgar.

Throop, A. W. (1993), A generalised uncovered interest parity model of exchange rates, *Federal Reserve Bank of San Francisco Economic Review*, 2: 3-16.

Wei, S. J. and Parsley, D. C. (1995), Purchasing power dis-parity during the floating rate period: exchange rate volatility, trade barriers and other culprits, *NBER Working Papers*, No. 5032.

World Bank (1993), *East Asia miracle: Economic growth and public policy*, Oxford: Oxford University Press.

Wu, J. L. (1996), The empirical investigation of long-run purchasing power parity: The case of Taiwan exchange rates, *International Economics Journal*, 10: 59-69.

Wu, Y. (1996), Are real exchange rates nonstationary? Evidence from a panel - data test, *Journal of Money, Credit and Banking*, 28: 54-63.

Zhou, S (1995), The response of real exchange rates to various economic shocks, *Southern Economic Journal*, 61: 936-54.

Zhou, S. and Mahdavi, S. (1996), Simple vs. generalized interest rate and purchasing power parity models of exchange rates, *The Quarterly Review of Economics and Finance*, 36: 197-218.

Yoshikawa, H. (1990), On the equilibrium yen-dollar rate, *American Economic Review*, 80: 576-83.

Appendix 1

The description of the variables

p_t	Price index, defined as the consumer price index.
s_t	The nominal exchange rate, defined as the units of domestic currency per unit of US dollar.
q_t	The real exchange rate, defined as nominal exchange rate adjusted to the domestic and foreign consumer price indices.
k	Number of lags.
n	Number of variables.
T	Traded goods
NT	Non-traded goods
$Poil_t$	The world real price of oil, defined as average crude oil price deflated by international Monetary Fund consumer price index.
$Prod_t$	The productivity difference, defined as difference in productivity index in the industrial production (or in manufacturing) between home and the foreign equivalent, or real GDP index between home and the foreign equivalent.
gs_t	The domestic government spending, defined as the ratio of general government expenditure to GDP.
gs_t^*	The US government spending, defined as the ratio of general government expenditure to GDP.
ρ_t	Relative price of non-tradables, defined as the price ratio of non-traded goods price to traded goods price.
h	h-step forecasting horizon

Appendix 2

Exchange rate regimes in East Asia

East Asian economies have put great emphasis on keeping their nominal exchange rates stable. Typically an East Asia government has tried to tie the value of its domestic currency loosely to a basket of currencies, but primarily to the US dollar. Now we briefly discuss the evolution of exchange rate regimes that East Asia countries adopted from early 1970s to recent years.

During the 1980s, most Asian countries deregulated and liberalised their domestic markets. Financial liberalisation has been taken for the purpose of increasing the efficiency of the domestic financial system by liberalising interest rates, reducing controls on credit, enhancing competition among financial institutions and encouraging the creation and development of money and capital markets. Together with this move towards the liberalisation of domestic financial markets, most Asian countries also undertook measures to relax international capital controls and to adopt more flexible exchange rate arrangements. The following is the description to each currency's arrangements.

Indonesia: The exchange rate system of Indonesia has been classified as managed floating by the International Monetary Fund after the country ended the fixed rate regime in November 1978, and a basket peg was established for the currency based on undisclosed currencies. The exchange rate is determined by Bank Indonesia (BI), under which the bank announces a daily "conversion rate bank" (for official transactions with foreign exchange banks, government, as well as with supranational institutes), and an "intervention band" consisting of buying and selling rates that are computed on the basis of a basket of currencies. The Asian currency crisis forced the government to allow the rupiah to float freely on August 14th, 1997.

Japan: Japan moved to the flexible exchange rate system in 1973. The exchange rate of the Japanese yen is determined on the basis of supply and demand. However, the authorities intervene when necessary in order to counter disorderly conditions in the markets. The principal intervention currency is the US dollar.

Malaysia: Malaysia placed the effective rate of its currency on a controlled floating basis in the early 1970s. In September 1975, the currency's controlled floating rate was linked to a basket of unspecified major trading partners' currencies. By the early 1980s, Malaysia abolished almost all controls in international capital flows that were not financed by local borrowing. Its value was tied to a trade-weighted basket and controlled by the central bank of Malaysia, Bank Negara. Bank Negara's stated policy is to allow the exchange rate to be generally market-determined, intervening only to maintain orderly market conditions and to avoid excessive fluctuations in the value of the ringgit. Bank Negara also monitors the exchange rate against a basket of currencies weighted in terms of Malaysia's major trading partners and currencies of settlement.

Korea: Korea maintained a fixed exchange rate against the dollar in the 1970s. In February 1980, its currency, the Korean won's fixed link to the US dollar was abandoned and a controlled, floating, effective rate was established. Since then, the Korean won joined the group of managed floating currencies. This rate is linked to the SDR and a basket of currencies of Korea's major trading partners. The bank of Korea uses an undisclosed basket of currencies, which is adjusted to reflect changes in the external position of the economy, as a guide for exchange rate management. The central bank actively intervenes in the markets to maintain the stability of its currency and keep the exchange rate at the level compatible with the government's economic policy.

Philippines: Prior to 1970, the peso had been fixed to the US dollar, with only one discretionary devaluation in 1963. During the 1970s, the Philippines effectively implemented a fixed exchange rate policy vis-à-vis the US dollar. In October 1984, a new exchange regime was established to replace the previous defacto multiple rate structure. The new regime permits the effective rate of the peso to be determined on the basis of demand and supply in the foreign exchange market, with periodic central bank intervention. The Bankko Sentral ng Philippines (BSP) intervenes when necessary to limit sharp fluctuations in the exchange rate and to maintain orderly conditions in the market.

Singapore: The Singapore dollar has been a managed floating currency ever since the breakdown of the Bretton Woods system. In June 1973 the effective rate of Singapore dollar was placed on a controlled floating basis with its rate determined by a trade-weighted basket of currencies. In 1978, the nation abolished all exchange controls on its currency. In 1985, the Singapore dollar was set free to float according to supply and demand on the foreign exchange market. However, The monetary authority of Singapore (MAS) frequently intervenes in the foreign exchange market to keep the value of the currency within a range determined by a basket of currencies set on a trade-weighted basis.

Thailand: From 1971 to March 1978, the Thai baht maintained fixed exchange rate arrangement by pegging its currency to the US dollar following its float in 1971. This regime came to an end when the country broke the link with the US dollar and established a controlled floating effective rate in 1978. The external value of the baht is determined on the basis of an undisclosed, weighted basket of currencies of Thailand's major trading partners. In July 1997, the baht went into free float.

According to the IMF classification, the exchange rate regimes in the East Asia up to the end of 1996 are summarised in Table A.1.

Table A.1 Current exchange rate regimes in East Asia

Currency	Exchange rate regime
Indonesia rapiah	Managed floating
Japanese yen	Independent floating
Korea won	Managed floating
Malaysia ringgit	Managed floating
Philippines peso	Independent floating
Singapore dollar	Managed floating
Thailand baht	Pegged

Source: Exchange arrangements and exchange restrictions, IMF Annual Report, 1997.

Appendix 3

Balassa-Samuelson hypothesis

Consider the case of a small, open economy, that produces both traded and non-traded goods. The sector Cobb-Douglas production functions are

$$Y^T = A^T (L^T)^{\theta^T} (K^T)^{1-\theta^T} \tag{A3.1a}$$

$$Y^{NT} = A^{NT} (L^{NT})^{\theta^{NT}} (K^{NT})^{1-\theta^{NT}} \tag{A3.1b}$$

where subscripts T and NT denote tradable and nontradable goods, Y denotes output, K capital, L labour input, and A total factor productivity. θs are coefficients from the sectoral production function. Assuming perfect capital mobility both internationally and across the two sectors internally. Under the perfect competition in both sectors, profit maximisation implies

$$R = (1-\theta^T) A^T (K^T / L^T)^{-\theta^T} \tag{A3.2a}$$

$$R = \rho(1-\theta^{NT}) A^{NT} (K^{NT} / L^{NT})^{-\theta^{NT}} \tag{A3.2b}$$

$$W = \theta^T A^T (K^T / L^T)^{1-\theta^T} \tag{A3.2c}$$

$$W = \rho\theta^{NT} A^{NT} (K^{NT} / L^{NT})^{1-\theta^{NT}} \tag{A3.2d}$$

where W is the wage rate measured in tradables, R is the rate of return on capital, and ρ is the relative price of nontradables. Perfect capital mobility and the law of one price in the tradable goods sector ensures that the rate of return on tradables, R, is equal to its world value. The key result is that with perfect capital mobility, the relative price of nontradables ρ is governed entirely by the production side of the economy. Equations (A3.2a) - (A3.2d) involve four variables in four equations, K^T/L^T, K^N/L^N, W, and R. The equations can be solved recursively as follows: Given the constant returns to scale production functions (A3.1a) and (A3.1b), equation (A3.2a) implies a unique level of K^T/L^T consistent with the world rate of return on capital R. Given K^T/L^T, equation (A3.2c) determines the economy-wide wage rate W. The remaining two equations (A3.2c) and (A3.2d) then determine K^N/L^N and ρ.

By log-differentiating equations (A3.2a) to (A3.2d), the generalisation of the classic Balassa-Samuelson hypothesis is obtained,

$$\hat{\rho} = (\theta^{NT} / \theta^{T})\hat{a}^{T} - \hat{a}^{NT} \qquad \text{(A3.3)}$$

where ^ denotes a rate of percentage change. If both sectors have the same degree of capital intensity, $\theta^{NT} = \theta^{T}$, then the percentage change in the relative price of non-traded goods is simply equal to $\hat{a}^{T} - \hat{a}^{NT}$, the productivity growth differential between the traded and non-traded sectors. If, however, $\theta^{NT} > \theta^{T}$, (one generally thinks of non-traded goods as being more labour intensive), then even balanced productivity growth ($\hat{a}^{T} = \hat{a}^{NT}$) will lead to an appreciation of the relative price of traded goods.

Appendix 4

Derivation of quarterly figures from annual data

Boot, Feibes and Lisman (1967)'s method is a pure mathematical approach which impose a prior conditions in order to get a 'reasonable' disaggregated series from a set of annual data without requiring preliminary estimates. They introduce a criteria based on minimising squared first differences. In other words, the approach is to minimise the sum of squared differences between the successive quarterly values, subject to the constraints that during each year the sum of the quarterly figures equals the annual total. Mathematically, if there are n years to minimise

$$\underset{x}{Min} \sum_{i=2}^{4n} (x_i - x_{i-1})^2, \qquad \text{(A4.1)}$$

Subject to

$$\sum_{i=4k-3}^{4k} x_i = t_k \quad (k = 1,2,\ldots n), \qquad \text{(A4.2)}$$

where x_i stands for the *i*th quarterly figure and t_k for the given yearly total in year k.

The problem is solved by considering the Lanrangean expression

$$\sum_{i=2}^{4n} (x_i - x_{i-1})^2 - \sum_{k=1}^{n} \lambda_k \Big(\sum_{i=4k-3}^{4k} x_i - t_k \Big) \qquad \text{(A4.3)}$$

Upon differentiating with respect to x_i (i=1,2,...,4n) and λ_k (k=1,2,...n) and equating the resulting expression to zero, 4n+n equations in 4n+n unknowns x_i and λ_k

$$\begin{bmatrix} B & -J' \\ J & 0 \end{bmatrix}\begin{bmatrix} x \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ t \end{bmatrix} \tag{A4.4}$$

where B is a band matrix of order 4n×4n, J is a convertor matrix of order n×4n, o is a null-matrix, and x is a column vector of n annual figures. The matrix A contains the coefficients of the x_is in the partial derivatives of the Lanrangean expression with respect to these x_is:

$$\begin{bmatrix} 2 & -2 & 0 & 0 & \ldots & 0 & 0 & 0 & 0 \\ -2 & 4 & -2 & 0 & \ldots & 0 & 0 & 0 & 0 \\ 0 & -2 & 4 & -2 & \ldots & 0 & 0 & 0 & 0 \\ & & & & & & & & \\ 0 & 0 & 0 & 0 & \ldots & -2 & 4 & -2 & 0 \\ 0 & 0 & 0 & 0 & \ldots & 0 & -2 & 4 & -2 \\ 0 & 0 & 0 & 0 & \ldots & 0 & 0 & -2 & 2 \end{bmatrix}$$

while the convertor matrix J is the Kronecker product of the identity matrix of order n and a row-vector of 4 ones:

$$\begin{bmatrix} 1 & 1 & 1 & 1 & \ldots & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & \ldots & 0 & 0 & 0 & 0 \end{bmatrix}$$

Appendix 5

The test of non-diagonal error variance matrix for each VAR

Now we test if shocks in different equations are not contemporaneously correlated by using the log-likelihood ratio statistics. Suppose it is of interest to test the hypothesis

$$\begin{aligned} H_0: \quad v_{12} = v_{13} = \cdots = v_{1n} &= 0 \\ v_{23} = \cdots = v_{2n} &= 0 \\ \ddots \quad v_{nn} &= 0 \end{aligned}$$

against the alternative that one or more of the off-diagonal elements of Σ are non-zero, that is

$$\begin{aligned} H_1: \quad v_{12} \neq v_{13} \neq \cdots \neq v_{1n} &\neq 0 \\ v_{23} \neq \cdots \neq v_{2n} &\neq 0 \\ \ddots \quad v_{nn} &\neq 0 \end{aligned}$$

where v_{ij} stands for the contemporaneous covariance between each of the two shocks.

The likelihood ratio statistics for testing this hypothesis is

$$LR = (H_0 / H_1) = 2(LL_U - LL_R) \qquad \text{(A5.1)}$$

where LL_U and LL_R are the maximised values of the log-likelihood function under H_1 (the unrestricted model) and under H_0 (the restrict model), respectively. Under H_0, LR is asymptotically distributed as a χ^2 with n(n-1)/2 degrees of freedom. Since there are five variables in our case, the degrees of freedom is ten. With this degrees of freedom, the critical value at 95% level is 18.3.

Table A.2 The test of non-diagonal error variance matrix for each VAR

	LL_U	LL_R	LR
Indonesia	854.27	821.74	65.05
Japan	1017.5	997.02	40.96
Malaysia	902.21	889.92	24.51
Philippines	675.30	663.9	22.8
Singapore	672.83	660.98	23.7
Thailand	843.12	811.23	63.78

The results from above test of non-diagonal error variance matrix for each VAR show that in all the cases it could totally reject the null hypothesis that the shocks are contemporaneous uncorrelated.

Appendix 6

Innovation accounting technique

A6.1 Impulse response function

Orthogonalized impulse response

Following Sims (1980, 1981), the dynamic analysis of vector autoregressivc (VAR) model is routinely carried out using the Choleski decomposition which makes the components of the residual vector orthogonal to each other. Since the covariance matrix Σ_v of a VAR(k) process is positive definite, there exists a non-singular matrix T such that $\Sigma = TT'$, where T is a lower triangular matrix. With this matrix the moving average representation[1] can be rewritten as

$$\begin{aligned} y_t &= \mu + \sum_{i=0}^{\infty} A_i T T^{-1} v_{t-i} \\ &= \mu + \sum_{i=0}^{\infty} \Psi_i \varepsilon_{t-i} \end{aligned} \tag{A6.1}$$

where $\Psi_i = A_i T$ and $\varepsilon_t = (\varepsilon_{1t}, \cdots \varepsilon_{nt})' = T^{-1} v_t$. It is now easily seen that

$$E(\varepsilon_t \varepsilon_t') = T^{-1} E(v_t v_t') T'^{-1} = T^{-1} \Sigma T'^{-1} = I$$

The new error vector ε_t, obtained using the transformation matrix, T, are now contemporaneously uncorrelated and all have unit standard errors. In other words, the shocks $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t} \cdots \varepsilon_{nt})'$ are orthogonal to each other. Hence the orthogonalized impulse response function of a 'unit shock' (equal to one standard error) at time t to the *i*th orthogonalized error, namely ε_{it}, on the *j*th variable at time t+N is given by

[1] See equation (8.2) in chapter 8.

$$OI_{ij,N} = e_j^{'} A_N T e_i, \quad i, j = 1, 2, \cdots n \qquad \text{(A6.2)}$$

where e_i is the n×1 selection vector with unity as its *j*th element and zeros elsewhere,

$$e_i = (0, 0, \ldots 0, \underset{\substack{\uparrow \\ i\text{th element}}}{1}, \ldots 0)' \qquad \text{(A6.3)}$$

In this case, it is reasonable to assume that a change in one component of ε_t has no effect on the other components, since the components are orthogonal (uncorrelated). Since the variances of the components are one, a unit innovation is just an innovation of one standard deviation. The elements of the Ψ_i are interpreted as responses of the system to such innovations. More precisely, the *jk*th element of Ψ_i is assumed to represent the effect on variable j of a unit innovation in the *k*th variable that has occurred i periods ago.

One problem is that these orthogonalized impulse responses are not unique, and in general, depend on the particular ordering of the variables in the VAR. However, the ordering of the variables cannot be determined with statistical methods but has to be specified by the analyst. The ordering has to be such that the first variable is the only one with a potential immediate impact on all other variables. The second variable may have an immediate impact on the last n-2 components of y_t but not on y_{1t}, and so on. To establish such an ordering may be a quite difficult exercise in practice. The orthogonalized responses are invariant to the ordering of the variables only if Σ_v is diagonal (or almost diagonal). The non-uniqueness of the orthogonalized impulse responses is also related to the non-uniqueness of the matrix in the Cholesky decomposition of Σ_v. Note that a multitude of T matrices with $TT^{'} = \Sigma_v$ exists and thus Ψ_i. The choice of T is made on the basis of a priori knowledge on the structure of the relationships between the variables of interest.

Unfortunately, a priori information that suggests a particular form of MA representation is not always available, and in such cases, the multiplier analysis has a certain degree of arbitrariness. If the appropriate T matrix is unknown, only conclusions that do not depend on it may be drawn from an impulse response analysis.

Generalised impulse response

As mentioned the orthogonalized impulse response is not invariant to the ordering of the variables in the VAR. To circumvent this problem, Koop *et al* (1996) have proposed using the generalised impulse response (GI), which was originally intended to deal with the problem of impulse response analysis in the case of non-linear dynamically systems. Pesaran and Shin (1998) developed this approach for use with multivariate time series models such as the VAR. This approach does not require orthogonalization of shocks and is invariant to the ordering of the variables in the VAR, and coincides with the similar analysis either for the first variable in the VAR or if Σ is diagonal.

An impulse response function measures the time profile of the effect of shocks at a given point in time on the (expected) future values of variables in a dynamic system. The best way to describe an impulse response is to view it as the outcome of a *conceptual* experiment in which the time profile of the effect of a hypothetical $n\times 1$ vector of shocks of size $\delta=(\delta_1,...,\delta_n)'$, say, hitting the economy at time t, is compared with a base-line profile at a time t+N. There are three main issues: (i) The types of shocks hitting the economy at time t; (ii) the state of the economy at time t-1 before being shocked; and (iii) the types of shocks expected to hit the economy from t+1 to t+N.

Denoting the known history of the economy up to time t-1 by the non-decreasing information set Ω_{t-1}, the generalised impulse response function of y_t at horizon N, advanced by Koop *et al* (1996), is defined by

$$GI_y(N,\delta,\Omega_{t-1}) = E(y_{t+N}|v_t = \delta, \Omega_{t-1}) - E(y_{t+N}|\Omega_{t-1}) \qquad \text{(A6.4)}$$

where $E(\cdot|\cdot)$ is the conditional mathematical expectation taken with respect to the VAR model (see equation 8.1), and Ω^0_{t-1} is a particular historical realisation of the process at time t-1. In the case of the VAR model having the infinite moving-average representation, we have $GI_y(N,\delta,\Omega_{t-1}) = A_N\delta$, which is independent of the "history" of the process, but depends on the composition of shocks defined by δ. This history invariance property of the impulse response is, however, specific to linear systems and does not carry over to the non-linear dynamic models, according to Pesaran and Shin (1998).

In practice, it could choose to shock only one element instead of shocking all the elements of v_t, say, its *i*th equation at time t, and integrate out the effects of other shocks using an assumed or the historically observed distribution of the errors. In this case we have

$$GI_y(N,\delta_j,\Omega_{t-1}) = E(y_{t+N}|v_{jt} = \delta_j, \Omega_{t-1}) - E(y_{t+N}|\Omega_{t-1}) \qquad \text{(A6.5)}$$

assuming that u_t has a multivariate nominal distribution, it is now easily seen that

$$E(v_t|v_{it} = \delta_i) = (\sigma_{1i}, \sigma_{2i}, \cdots \sigma_{ni})' \, \sigma_{ii}^{-1} \, \delta_i \qquad \text{(A6.6)}$$

Hence, for a unit shock defined by $\delta_i = \sqrt{\sigma_{ii}}$, the generalised impulse response function of a unit shock to the *i*th equation in the VAR model on the *j*th variable at horizon N is given by

$$GI_{ij,N} = \frac{e_j' A_N \Sigma e_i}{\sqrt{\sigma_{ii}}}, \quad i, j = 1, 2, ..., n, \tag{A6.7}$$

where e_i is the $n \times 1$ selection vector given by (A6.3). Unlike the orthogonalized impulse responses in (A6.2), the generalised impulse responses in (A6.7) are invariant to the ordering of the variables in the VAR. The relationship between the generalised and orthogonalized impulse response can be seen in Pesaran and Shin (1998).

A6.2 Forecast error variance decomposition

Orthogonalized variance decomposition

The MA representation can offer a further possibility to interpret a VAR(k) model, *ie*, decompose the variance of the forecast errors of the variables in the VAR at different horizons. In the context of the orthogonalized moving average representation of the VAR given by (A6.1), the forecast error decomposition for the *i*th variable in the VAR is given by

$$\theta^{o}_{ij,h} = \frac{\sum_{l=0}^{h} (e_i' A_l T e_j)^2}{\sum_{l=0}^{h} e_i' A_l \Sigma A_l' e_i} \quad \text{i, j = 1,2,...,n.} \tag{A6.8}$$

where T is defined by the Cholesky decomposition of Σ; e_i is the selection vector defined by (A6.3); and $A_l, l = 0,1,2,...,$ are the coefficient matrices in the moving average representation in (8.2).

$\theta^{o}_{ij,h}$ measures the proportion of the h-step ahead forecast error variance of variable i, which is accounted for by the orthogonalized innovations in variable j. This is the way the forecast error variance is decomposed into components accounted for by innovations in different variables of the system. For further details, see Lükepohl (1991).[2] Note that by construction $\sum_{j=1}^{n}\theta^{o}_{ij,h}=1$. As with the orthogonalized impulse response function, the orthogonalized forecast error variance decompositions in (A6.8) are not invariant to the ordering of the variables in the VAR.

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[2] In terms of the representation

$$y_t = \mu + \sum_{i=0}^{\infty}\Psi_i \varepsilon_{t-i} \tag{1}$$

with $\Sigma_\varepsilon = I$, the error of the optimal h-step forecast is

$$\begin{aligned} y_{t+h} - y_t(h) &= \sum_{l=0}^{h-1} A_l v_{t+h-l} = \sum_{l=0}^{h-1} A_l T T^{-1} v_{t+h-l} \\ &= \sum_{l=0}^{h-1}\Psi_l \varepsilon_{t+h-l} \end{aligned} \tag{2}$$

denoting the mn-th element of Ψ_l by $\varphi_{mn,l}$, the h-step forecast error of the i-th component of y_t is

$$\begin{aligned} y_{i,t+h} - y_{i,t}(h) &= \sum_{l=0}^{h-1}\varphi_{i1,l}\varepsilon_{1,t+h-l} + \ldots + \varphi_{in,l}\varepsilon_{n,t+h-l} \\ &= \sum_{j=1}^{n}\varphi_{ij,0}\varepsilon_{j,t+h} + \ldots + \varphi_{ij,h-1}\varepsilon_{j,t+1} \end{aligned} \tag{3}$$

Thus, the forecast error of the i-th component potentially consists of innovations of all other components of y_t as well. Since the $\varepsilon_{j,t}$ are uncorrelated and have variance one, the MSE of $y_{i,t}(h)$ is

$$E(y_{i,t+h} - y_{i,t}(h))^2 = \sum_{j=1}^{n}(\varphi^2_{ij,0} + \ldots + \varphi^2_{ij,h-1})$$

Therefore

$$\varphi^2_{ij,0} + \varphi^2_{ij,1} + \ldots + \varphi^2_{ij,h-1} = \sum_{l=0}^{h-1}(e_i'\Psi_l e_j)^2 \tag{4}$$

is sometimes interpreted as contribution of innovations in variable j to the forecast error variance or MSE of the h-step forecast of variable i. Here e_l is the l-th column of I. Dividing (4) by

$$MSE[y_{i,t}(h)] = \sum_{l=0}^{h-1}\sum_{j=1}^{n}\varphi^2_{ij,l}$$

gives

$$\theta^o_{ij,h} = \sum_{l=0}^{h-1}(e_i'\Psi_l e_j)^2 \Big/ \sum_{l=0}^{h-1} e_i' A_l \Sigma A_l' e_i \tag{5}$$

Generalised variance decomposition

The above generalised impulse can also be used in the derivation of the forecast error variance decompositions by considering the proportion of the h-step forecast errors of y_t which in explained by conditioning on the non-orthogonalized shocks, v_{it}, $v_{i,t+1}$, ..., $v_{i,t+h}$, but explicitly to allow for the contemporaneous correlations between these shocks and the shocks to the other equations in the system.

Using the MA representation (8.2), the forecast error of predicting y_{t+h} conditional on the information at time t-1 is given by

$$\xi_t(h) = \sum_{l}^{h} A_l v_{t+h-l} \qquad \text{(A6.9)}$$

with the *total* forecast error covariance matrix

$$Cov(\xi_t(h)) = \sum_{l=0}^{h} A_l \Sigma A_l^{'} \qquad \text{(A6.10)}$$

Consider now the forecast error covariance matrix of predicting y_{t+h} conditional on the information at time t-1, and the given values of the shocks to the *i*th equation, v_{it}, $v_{i,t+1}$, ..., $v_{i,t+h}$. Using (8.2), we have

$$\xi_t^{(i)}(h) = \sum_{l=0}^{h} A_l (v_{t+h-l} - E(v_{t+h-l} | v_{i,t+h-l})) \qquad \text{(A6.11)}$$

As in the case of the generalised impulse responses, assuming $v_t \sim N(0, \Sigma)$, we have

$$E(v_{t+h-l} | v_{i,t+h-l}) = (\sigma_{ii}^{-1} \Sigma e_i) v_{i,t+h-l} \qquad \text{for} \qquad \begin{array}{l} l = 0,1,2,\ldots,h \\ i = 1,2,\ldots,n \end{array}$$

Substituting this result back in (A6.11),

$$\xi_t^{(i)}(h) = \sum_{l}^{h} A_l (v_{t+h-l} - \sigma_{ii}^{-1} \Sigma e_i v_{i,t+h-l})$$

and taking unconditional expectations, yields

$$Cov(\xi_t^{(i)}(h)) = \sum_{l=0}^{h} A_l \Sigma A_l' - \sigma_{ii}^{-1}(\sum_{l=0}^{h} A_l \Sigma e_i e_i' \Sigma A_l') \qquad (A6.12)$$

Therefore, using (A6.10) and (A6.12), it follows that the decline in the h-step forecast error variance of y_t obtained as a result of conditioning on the future shocks to the *i*th equation is given by

$$\begin{aligned} \Delta_{ih} &= Cov[\xi_t(h)] - Cov[\xi_t^{(i)}(h)] \\ &= \sigma_{ii}^{-1} \sum_{l=0}^{h} A_l \Sigma e_i e_i' \Sigma A_l' \end{aligned} \qquad (A6.13)$$

Scaling the *j*th diagonal element of Δ_{ih}, namely $e_j' \Delta_{ih} e_j$, by the h-step ahead forecast error variance of the *i*th variable in y_t, we have the following generalised forecast error variance decomposition:

$$\theta_{ij}^{g}(h) = \frac{\sigma_{ii}^{-1}(\sum_{l=0}^{h} e_j' A_l \Sigma A_l')}{\sum_{l=0}^{h} e_i' A_l \Sigma A_l' e_i} \qquad (A6.14)$$

Note that the denominator of this measure is the *i*th diagonal element of the total forecast error variance in (A6.10) and is the same as the denominator of the orthogonalized forecast error variance decomposition formula (A6.8). Note also that due to the non-zero covariance between the original shocks, in general $\sum_{j=1}^{n} \theta_{ij,h}^{g} \neq 1$.

A6.3 Impulse response in a cointegrating VAR system

The simple VAR based on differenced data fails to provide an adequate explanation for the behaviour of a group of integrated variables when those variables are cointegrated, such as in our example. In the presence of cointegration relationships, it is necessary to estimate the

VAR model in an error-correction form so as to avoid "throwing away" information concerning comovements in data.

Orthogonalized impulse response in the cointegrated VAR

The impulse response analysis of the cointegrating model can be carried along the lines set out in the above sections. In the present application, it is important that the parameter restrictions implied by the deficiency in the rank of the long-run matrix, Π, is taken into account. It is also important to note that, due to the rank deficiency of the long-run matrix, shocks (whether equation-specific or system-wide) will have persistent effects on the individual variables in the model, and their effects will generally not die out.

The computation of the impulse response function for the cointegrating VAR model can be based on the VECM as follows,

$$\Delta y_t = \mu_0 + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-1} + \varepsilon_t \qquad \text{(A6.15)}$$

where

$$\Gamma_i = -(I - \Phi_1 - \ldots - \Phi_i) \qquad i = (1, \ldots, k\text{-}1)$$

and $$\Pi = -(I - \Phi_1 - \ldots - \Phi_k)$$

The n×n matrix Π can be expressed as $\Pi = \alpha \times \beta'$, where α is the n×r matrix and β is the r×n matrix which both have rank r. Here β is a matrix representing the cointegration relations such that $\beta' y_t$ is stationary. Under the assumption, y_t will be first difference stationary, and therefore, Δy_t can be written as the infinite moving average representation,

$$\Delta y_t = \gamma_0 + \sum_{i=0}^{\infty} C_i v_{t-i} \qquad \text{(A6.16)}$$

EN

The orthogonalized impulse response function of the effect of a unit shock to the ith variable at time t on the jth variable at time t+N is given by

$$OI_{ij,N} = e_j' \,(C(1) + C_N^*)\, Te_i \tag{A6.17}$$

where, as before, T is a lower triangular matrix such that $\Sigma = TT'$, e_i is the selection vector defined by (A6.3), and C(1) and C_N^* are defined as follows

$$C(L) = C(1) + (1-L)C^*(L) \tag{A6.18}$$

$$C^*(L) = \sum_{i=0}^{\infty} C_i^* L^i \tag{A6.19}$$

where L is the one-period lag operator and the n × n matrices, C_i^*, are obtained recursively from

$$C_i^* = C_{i-1}^*\Phi_1 + \cdots + C_{i-k}^*\Phi_k\,, \quad i = 1,2,\cdots \tag{A6.20}$$

with $C_0^* = I_m - C(1), \quad C_i^* = 0, \quad i < 0,$ and

$$\Pi C(1) = 0 = C(1)\Pi \tag{A6.21}$$

The matrices, Φ_1, Φ_2, ..., Φ_k are the coefficient matrices in the VAR form of (8.2), and in terms of Π, Γ_1, Γ_2, ..., and Γ_{k-1} are given by

$$\begin{aligned}
\Phi_1 &= I_n - \Pi + \Gamma_1 \\
\Phi_i &= \Gamma_i - \Gamma_{i-1} \qquad\qquad i = 2,3,\ldots,k-1 \\
\Phi_k &= -\Gamma_{k-1}
\end{aligned}$$

Alternatively, let

$$A_i = C(1) + C_i^* \tag{A6.22}$$

Then substituting $C_i^* = A_i - C(1)$ in (A6.20) and using (A6.21) it also follows that

$$A_i = A_{i-1}\Phi_i + \cdots + A_{i-k}\Phi_k\,, \quad i = 1,2,\cdots \tag{A6.23}$$

where $A_0=I_m$, and $A_i=0$, for $i<0$. However, from (A6.22) it is clear that

$$\lim_{i\to\infty} A_i = C(1) \tag{A6.24}$$

which is a non-zero matrix with rank n-r. Therefore, the orthogonalized impulse responses for the cointegrating VAR model can be computed in exactly the same way as in the case of stationary VAR models. The main difference is that the matrices, A_i, in the moving averaging representation of the y_t -process tend to zero when the underlying VAR model is trend-stationary, and tend to a non-zero rank deficient matrix C(1), when the underlying VAR model is first stationary.

The generalised impulse response function, and the orthogonalized and the generalised forecast error variance decomposition can also be computed for the cointegrating VAR models, along similar lines to sections A6.1 and A6.2.

Impulse response functions of cointegrating relations

In cointegrated systems it is sometimes of interest to know in what way and how fast the variables return to the equilibrium relation after the equilibrium has been disturbed (e.g. Pesaran and shin, 1996; Mellander *et al*, 1992). This is to consider the effect of the shocks on the cointegrating relations, $\beta' y_t$, rather than on the individual variables in the model. These responses to disturbances of the equilibrium can be obtaincd from the previously discussed impulse responses by pre-multiplying with the cointegration matrix. Considering the effect of a unit shock to the variable in y_t on the *j*th cointegrating relation, namely $\beta_j' y_t$, the time profiles for both orthogonalized and generalised approaches can be shown in the following

$$OI_i(\beta_j' y_t, N) = \beta_j' A_N T e_i \tag{A6.25}$$

and
$$GI_i(\beta_j' y_t, N) = \frac{\beta_j' A_N T e_i}{\sqrt{\sigma_{ii}}} \tag{A6.26}$$

for i=1,2,...n, j=1,2,...,r, N=0,1,2,....which give the responses of a unit change in the *i*th orthogonalized (or generalised) shock on the *j*th cointegrating relation. The two impulse response functions coincide if Σ is diagonal.

A6.4 Persistence profiles

Pesaran and Shin (1996) propose persistence profiles as measures of the effects of system - wide shocks to the variables. In unscaled form they are the elements of $A_i \Sigma_v A_i'$. The scaled counterparts of the effect of system -wide shocks on the *j*th cointegrating relationship is given by

$$h(\beta_j' y_t, N) = \frac{\beta_j' A_N \Sigma A_N' \beta_j}{\beta_j' \Sigma \beta_j} \tag{A6.27}$$

for j=1,2,...r, and N=0,1,2,.... The value of this profile is equal to unity on impact, but should tend to zero as N $\rightarrow \infty$, if β_j is indeed a cointegrating vector. The persistence profile, $h(\beta_j' y_t, N)$, viewed as a function of N provides important information on the speed with which the effect of system-wide shocks on the cointegrating relationship, $\beta_j' y_t$, disappears, even though these shocks generally have lasting impacts on the individual variables in y_t.